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THE DAWN OF MODERN CHEMISTRY.

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THE period of the history of chemistry which I have chosen to designate as the dawn of modern chemistry begins practically in the early sixteenth century and extends well toward the latter part of the eighteenth century. Not that the chemistry of that period shows any very clear relation to the present state of chemical science, but because at about the middle of the sixteenth century there was inaugurated an era of activity in chemical thought and experimentation, which has continued with steadily increasing velocity and productiveness to the present time. The period referred to does not by any means mark the beginnings of chemical arts or theories, for the beginnings of the technical arts of chemistry may be traced back as far as recorded history. The earliest records of Egyptian or Babylonian origin show that the arts of metallurgy, the making of bronzes and other alloys, have been practised, and uninterruptedly so, since at least some 3,500 years before the Christian era. So also the manufacture of glass and pottery, the coloring of glass and pottery, the manufacture of colors for dyeing and painting, are of great antiquity. It is worthy of note also that these technical arts of chemistry possessed since very ancient times a kind of literature of their own in the form of recipes and directions for the various processes of the special art. Such manuscripts were doubtless not meant for public information, but for the use of the artisan alone, and were transmitted from the master to the apprentice or successor for his own use. The earliest original manuscript of this character known to exist is a manuscript on papyrus written in the Greek language which was discovered in an Egyptian tomb at Thebes, and is now preserved at Leyden. It dates from the third century of our era, and was doubtless a manuscript which escaped the wholesale destruction of alchemical and magical works in A.D. 290 by order of the Emperor Diocletian, issued, as believed, to prevent the danger of the possible making of gold by the alchemists and its resulting influence upon the

currency system of the Empire. This work consists of recipes for the testing of metals, their purification, their alloying, making of bronzes and brasses, the coloring of metallic objects by superficial alloying, imitations of gold, writing in gold letters, preparation of purple colors, etc. Some hundred recipes in all are contained in this manuscript. It is evidently based upon earlier works of similar character, and indeed earlier works whose contents have been preserved to us through the mediation of copies or abstracts by later writers evidence that the ideas and methods were doubtless mostly centuries old when this papyrus manuscript of Leyden was written. The researches of scholars, notably of Berthelot, have shown how very similar, in many cases identical, recipes to those of the papyrus of Leyden have been transmitted through Roman, Arabic and later languages in manuscript form, probably uninterruptedly in Europe down to the beginning of the printing of books.

It is believed that the Greeks originally derived their knowledge of the chemical arts largely from Egypt, but that the ancient Greek philosophers were the first to divorce the philosophy of chemistry from the religious ideas and magical notions of the Egyptian priesthood which with them obscured the logical reasoning from cause to effect, or from effect to cause. However that may be, the Greeks were the first sources of natural philosophy for European thought. And such names as Thales, Democritus, Pythagoras, Plato and Aristotle are names that characterize the period of the height of clarity of Greek philosophy somewhere from about 600 to 300 B.C.

At about the time when this papyrus of Leyden was written the so-called Alexandrian School of Greek philosophers was dominant. This later period of Greek philosophy was marked by much brilliancy and genius, but was also characterized by a distinct influence from Egyptian sources of oriental mysticism and occult philosophy.

The Romans were the natural inheritors of Greek thought, and the Roman conquest of the civilized and much of the uncivilized world again operated to spread the useful arts of chemistry as known to the ancients, though Roman influence did not contribute greatly to generalizing thought.

In A.D. 489 the Alexandrian Academy was destroyed by the Emperor Zeno and its Greek scholars scattered. A body of these, mainly Syrians, established themselves in Persia, where they continued the study and teaching of the science of the Alexandrian school.

Barbaric invasion resulted in almost complete extinction of the remains of Greek civilization in Europe. The Syrians in Persia were the principal conservators of ancient science, and they continued to preserve and reproduce the works of the ancient Greek writers.

In the seventh century occurred the great Mohammedan conquest of the Mediterranean countries. The conquering Moslems overran

Persia and Syria. Fortunately they were impressed by the Syrian scholarship, and Syrian scholars were given place in the courts of the Caliphs, and such works of the science of the ancient Greeks as were in their possession were translated into Syriac and Arabic, and thus such authors as Euclid, Archimedes, Ptolemy, Hippocrates, Galen, Zosimus and Aristotle became accessible to Arabian scholars and served as the foundation to the science of the Arabians.

In the eleventh and twelfth centuries these Syrian schools were in their turn suppressed by Mohammedan fanatics and the Arabians themselves became the principal guardians of ancient science. Arabian translations of Greek authorities and the works of Arabian commentators, often translated into Latin, became the authoritative sources of medieval science. So completely indeed had the original Greek works disappeared from Europe that later centuries assumed that the Arabians were the originators of much that they merely acquired and transmitted from the ancient Greeks and Egyptians through Syrian and Arabian translations. Arabian physicians, astronomers, mathematicians and alchemists became the teachers of science to the Europe of the middle ages.

The original literature of the ancient world having practically disappeared from Europe during the early middle ages, science and philosophy had reached a low ebb. The medieval Christian Church was also discouraging in its attitude toward scientific discovery and philosophic reasoning. Clerical authorities and the scholastic learning became more and more intolerant of dissenting opinions or any kind of free thought. Stagnation in science was the consequence, especially in the natural sciences. In medicine, for example, experiment and independent observation hardly existed. The works of Avicenna, Averroes, Mesue and other Arabian interpreters of the Greek authors Galen and Hippocrates were the recognized authorities, and even in the universities of the fourteenth and fifteenth centuries, the teaching of medicine consisted in reading and expounding the works of these authors. The works of Galen and Hippocrates themselves were indeed hardly known in their original purity, but as elaborated with infusions of Arabian mysticism and superstitions, symbolism and astrology.

Other sciences exhibited similar tendencies. Astronomy had degenerated from the rationality of Pythagoras or of Ptolemy into a stereotyped Ptolemaism mixed with astrology. The doctrines of Aristotle as interpreted and corrupted by similar influences were the accepted natural philosophy. The condition of chemistry was similar. While mining, metallurgy and other ancient arts of chemistry maintained their continuity in spite of barbarian invasions or Mohammedan conquests, and gradually added to their store of useful facts, the generalizations or theories which have always been essential to great advances in science had deteriorated to a condition which might be

called rudimentary even as compared with the earlier chemical philosophy of Thales, Democritus or Aristotle. The early Greeks had at least reasoned logically from the limited knowledge in their possession. That their generalizations were often more metaphysical than scientific resulted from the fact that their deductions were not based so much on experiment as upon the observation of the more obvious natural phenomena. And, however valuable metaphysical reasoning may be for intellectual discipline, or as a tool in the critical analysis of observed phenomena and their relations, it can not go beyond the facts involved in its premises and can not materially advance the development of experimental sciences. Thus it is safe to say that up to the fourteenth or fifteenth centuries the natural and physical sciences presented few advances and much retrogression from the best days of ancient Greek science.

Arabian scholarship, however it may have contributed to mathematics, astronomy and certain fields of physics, had brought to chemistry little new of value and much of confusion of mysticism and superstition. This statement is largely justified by the results of modern critical investigation which have shown that the works of chemical character attributed to the authorship of Gheber, Avicenna and other Arabian authors are quite generally fabrications of the twelfth to fifteenth centuries, published under those names either to obtain a wider circulation or to avoid the unpleasant consequences that might visit the real authors for dabbling in a suspected or forbidden art. Just as the medical science of the early Renaissance was a medley of Greek Galenism, oriental mysticism and medieval superstition, so the chemical philosophy of the time was a medley of Aristotelian philosophy, with similar infusions of oriental occultism. Many chemical substances were known which to Greeks or Egyptians were unknown—but in so far as any valuable body of theory is concerned, hardly an advance had been made. The chemical theory of the time was mainly of Greek and Egyptian origin filtered, as we have seen, through the Syrian and Arabian sources and for centuries nearly without material progress.

Let me attempt to present the main fundamental concepts of the nature of matter and its changes which constituted the generally accepted chemical theory at the beginning of the sixteenth century, whence we date the revival of chemistry.

The ancient Greeks entertained a very persistent notion of the essential unity of matter. They differed at various times and in different schools of natural philosophy as to the formulation of this theory. Thus some considered that water was the primal element from which all others had been developed, others considered the air as the primal element, others fire. Aristotle finally formulated the notion of the constitution of matter which became the most generally accepted

theory in later centuries. This was the theory of the five elements—fire, air, water, earth and ether or essence. It seems very probable that this theory was derived originally from ancient Hindoo philosophy, because in ancient Hindoo classics it is more completely elaborated than by Aristotle. The four elements—air, fire, water, earth—were not considered as distinct elementary substances, according to our modern definition of an element, but rather as determining qualities.

Thus fire combined the qualities of warmth and dryness; air—warmth and moistness; water—cold and moistness; earth—cold and dryness. All substances were considered as combinations of these elementary qualities, or in some sense as composed of these elements. The fifth element, ether or "essence," was more subtle and less clearly defined. It was supposed to be capable of taking all forms, and finally came to be identified with the "materia prima," or primal matter, out of which all other forms of matter were supposed to be born.

The Aristotelian notion of the four elements also implied the possibility of the change of one element to another. Thus when water evaporated by heat it became air; that is, by the addition of warmth, it changed from *cold and moist* to *warm and moist,* the properties of air. This idea among later alchemists served to justify the notion of the transmutability of the elements, that will-o'-the-wisp of chemists for many centuries. But this idea of the possibility of transmuting one element into another as of the baser metals into gold and silver received greater vitality from the observations and experiences of the metallurgists upon the occurrence, preparation and alloys of the metals,

The metals known to the ancients were seven in number, gold, silver, lead, mercury, iron, copper and tin, though they were not considered as elements. Other metals indeed entered into their alloys, but they were not recognized by them as separate or distinct from those already named. Arsenic was known, though not considered as a metal. Bismuth and zinc and antimony began to be recognized as distinct substances about the beginning of the sixteenth century. As methods of analysis were rudimentary even at this later date, and as there was no realization of the concept of an element of unvarying composition and properties, and as the metals were obtained in varying degrees of purity or admixture, it can be understood how the changes in appearance and properties of the metals, as obtained from their ores, was believed to be due to a partial transmutation in the Aristotelian sense.

In the alloying of various metals, the character of the alloys was changed in ways that easily suggested actual changes in the character of the metals themselves. Thus we know that the Egyptians considered certain alloys of gold and silver as a distinct metal "electrum." The frequent occurrence of some gold in silver as obtained from its ores also easily suggested the idea that this gold had in some way been produced from the silver.

Hence, if by alloying certain metals they obtained a metal resembling gold in color, this was perhaps really an approach to making gold, and, if it had been possible to make such an alloy by any combination of materials as should answer all their known tests for gold, from their standpoint it might well be real gold.

We can comprehend that if we considered an element only as a combination of certain qualities and not as a specific simple substance—there would be no a priori improbability in such an hypothesis.

Thus the experience of the chemists with the metals was the real motive force in vitalizing and in modifying the ideas of the Greek philosophers with respect to the nature of matter and its changes. The attempt to imitate precious stones was another line of work which helped to confirm these theories, though it may well be doubted whether in all cases the alchemists were self-deceived as to their success in producing the real articles even when they succeeded in passing them off as genuine.

Nevertheless the accepted theory of the essential unity of matter and of the possibility of transmuting one element or substance into another was the working hypothesis that kept the alchemists, for so many centuries, at their vain labors. As the study of the metals and their uses formed so large a part of chemical activity, there also grew up in time special theories as to the origin and changes of metals. One of the oldest of these can also be traced to the Egyptians and to Plato—the notion that mercury bears a peculiar relation to the origin of the metals. Among the Egyptians lead occupied a similar position, but the substitution of mercury in this rôle took place as early as Plato.

The very peculiar properties of mercury—argentum vivum, the liquid living silver, quick-silver—and the strange manner in which it lost its identity in combination and in alloys with other metals gave rise to a theory that it was the source of the other metals. And again, as with other metals, it might not always be the same in composition and properties, the idea developed that not the ordinary mercury, but a mystical purified mercury—the so-called "mercury of the philosophers" was a constituting element in all the metals.

So also sulphur bore a prominent relation to the occurrence and to the furnace reactions of metallic ores. Its combustibility, its frequent presence in metallic ores, the combinations with metals and the colors of these combinations—the red or black of its mercury combinations—the black copper compound—the yellow or red of arsenic compounds—etc., endowed it also with a mysterious relation to the metals, and it also became considered as a constituting element of the metals. Arsenic, which acts very similarly to sulphur in many such compounds, was sometimes associated with it in that rôle. And here again was assumed not ordinary sulphur, but a fancied perfect sulphur—the "sulphur of the philosophers."

Again the seven metals were associated with the seven planets of the ancients—gold with the sun, silver with the moon, copper with Venus, lead with Saturn, iron with Mars, mercury with Mercury, tin with Jupiter, and these planets were supposed to exert influences upon the generation and development or perfection of the metals in the earth. The base metals were often supposed to be undergoing a gradual development toward perfection. This development toward perfection, that is, toward silver and gold, might be influenced by many factors, such as the relative quantities of their sulphurs or their mercuries, the relative purity or degree of perfection of these mercuries or sulphurs, the time and local conditions of their position in the earth and the influences of their planets. It was not considered improbable that chemists might by experiment devise means to hasten this natural growth.

These notions I believe fairly summarize the quite generally entertained theories which make up the representative chemical theory at the beginning of the sixteenth century. But this beginning of the sixteenth century is the period of the full flower of the Renaissance. The first impulse to this period of remarkable activity in all domains of human thought originated in Italy, and at least as early as the thirteenth century. It began with a renewed interest in ancient Greek and Roman literature and art, naturally also a fresh interest in philosophy. It was fostered by the Florentine Academy under the protection of the Medici, though its influence soon spread to other parts of Europe. A new spirit of criticism was awakened, and even the church was invaded by a long-forgotten stimulus to freedom of thought and discussion. As the movement spread, the aroused interest of men in all domains of human activity gave rise to many great movements. In the thirteenth century were founded the universities of Padua, Bologna, Salerno, Salamanca, Paris, Montpelier, Oxford and Cambridge. Some of these trace their foundation to clerical schools of even earlier date—but grew to importance and influence under the new impulse.

In the fourteenth century the German universities of Vienna, Prague and Heidelberg were founded, and the fifteenth century was marked by a rapid increase in the number of German and French universities and in their influence. An influence of similar importance to that of the universities of the time—and perhaps even surpassing that influence—arose from the invention of printing from movable metal types which occurred about the middle of the fifteenth century. The revival of interest in ancient literature as well as the promulgation of new ideas was vastly stimulated by the possibility of making written works accessible to a vastly increased constituency, and the interchange of information and ideas thus made possible contributed enormously to the great intellectual development which we call the renaissance. The

civilized world became stimulated to new thoughts and to new enterprises, one might almost say it became intoxicated with great ideas and great ventures.

Natural science was the last field of thought to feel the new impulse, and in chemistry there was little evidence of progress until the sixteenth century. The representative chemical authors known to the fifteenth century were Arnald of Villanova, the unknown writers who wrote under the name of Raimundus Lullus (or Lully) and unknown writers who wrote chemistry under the name of Gheber, or of Albertus Magnus. All these writings were obscure in style and contributed little to the knowledge of chemistry or to clear thinking. The chemists of the period might be classified into two groups—artisans who were not generally of university education, working by traditional methods in their respective arts and not addicted to writing or philosophizing; and the learned class, usually physicians, sometimes clericals. Some interest in chemistry existed but was mainly confined to the efforts to discover the transmutation of metals or the elixir of life. Chemical facts were at times developed by their efforts, but disappointments and disillusions had brought the chemical theories of the ancients and alchemists into general stagnation and disrepute. Cornelius Agrippa, writing about 1530, quotes a proverb of the time—"An alchymist is either a physician or a soap boiler."

Four men notably mark the beginning of a new era in chemical activity, Theophrastus von Hohenheim (called Paracelsus), Georg Bauer (called Agricola), Vannuccio Biringuccio and Bernard Palissy.

Paracelsus was born in Switzerland in 1493; Agricola in Saxony in 1494; Biringuccio of Siena, Italy, probably about the same time; while Palissy was born in France and his birth year is variously given as 1499 and 1510.

We can better appreciate the stimulating intellectual atmosphere of the period in which these men lived if we recall that the span of their lives touched the life times of Michelangelo, Macchiavelli. Leonardo da Vinci, Ariosto, Rafael, Rabelais, Copernicus, Vesalius, Thomas More, Columbus, Cortez, Cardanus, Martin Luther, Erasmus and Savonarola.

Three of the four chemists mentioned—Agricola, Biringuccio and Palissy—may be said, each in his own line and country, to have laid the foundations of modern chemical technology. Each of them wrote an almost epoch-making work in a particular field of applied chemistry and exerted a powerful impetus toward raising the profession of technical chemist above the rank of Agrippa's "soap-boiler."

Biringuccio's work was published in 1540 in Italian under the title of "Pirotechnia." It treats of the metals, the semi-metals, their ores and minerals, and of some salts; of the alloys of the metals, their manufacture and uses. It contains also recipes for the use of the goldsmiths, the potters and other artisans. It is important as an

attempt to give a sober, sensible and intelligent description of the technical chemistry within his knowledge. It is interesting also because it preceded the greater work of Agricola by about sixteen years and is mentioned by the latter as having been in his hands, though it contained little that was of use to him.

While Biringuccio is known only through his one book, the works of Agricola are more numerous. They are chiefly upon minerology, mining or geology. He began publishing about 1530, but his great work, "De re Metallic," appeared in 1556. Agricola was a man of university training, and a scholar of fine type. He had studied in Italy and was a physician by profession. He was city physician at Joachimsthal in Bohemia, and later at Chemnitz in Saxony. His location in these mining centers gave him ample opportunity to become interested in mining and mineralogy and in the chemical operations used in metallurgy and assaying. The great work above referred to is for the time a very remarkably clear description of the operations of mining, smelting and assaying, with very complete description of the chemistry of these arts as known to the miners of the time and region. He does not claim apparently to have contributed original work to these arts, but the work of Agricola may justly be considered as the first really great work in the line of the scientific presentation of a chemical industry, a worthy pioneer to the many great technical works which have since appeared in so many lines of chemical industry. Its influence in its own field was immediate, as shown by the later editions called for and even still more by the number of similar though less important treatises which followed its appearance.

Bernard Palissy was a man of much less scholarship than Agricola. What he lacked in that respect he compensated for in an unconquerable enthusiasm in experimentation in the field which most interested him—the making of pottery and its glazes and enamels. He was a real investigator in his field, and his published works describe his experiments and discuss them clearly with neither the dogmatism nor the mystical jargon that most chemical writings of the previous centuries, or even of the subsequent century, exhibit. His works published between 1557 and 1580 may be said to have done much the same for the arts of the potter that the work of Agricola did for mining and the chemistry of metallurgy, with the difference that Palissy's work was rather a presentation of the result of his own labors than a complete compendium of existing knowledge and practise as was the "De re Metallica."

It can not be claimed either for Agricola or for Palissy that they were free from the prevalent superstitions or mystical ideas that were almost universally entertained in their century—but it can be asserted that they kept their constructive labor and thought free from obstruction from such notions. Both repudiated the transmutation ideas of the alchemists as vain and profitless, and both endeavored to make their

knowledge and their ideas as comprehensible as possible for their successors or contemporaries. Theirs was the spirit of service and that is also the spirit of modern science.

The work of these three chemists, however scientific its spirit and method, was not such as to affect immediately the thought of the time in lines outside of the industries they represented, nor to influence the chemical notions of the university faculties—mainly interested in philosophy and medicine.

The fundamental basis of chemical theory of the middle ages—the rudimentary chemical philosophy of the Greek-Arabian philosophers and alchemists—was not seriously affected by the work of these pioneers.

It is to Paracelsus that we are indebted for the impetus that was to inaugurate a broader and livelier interest in chemical activity and in chemical theories. Paracelsus was a man of very different type from his three colleagues already mentioned. A physician by training and profession, as his father was before him, he had traveled much and far—from Sweden to Italy, and from France to Bohemia—as an army surgeon, student or itinerant doctor. Brought up in childhood and in early manhood in mining countries, he had early become interested in the chemistry of the metals and had himself worked in the laboratories of the mines. He was a man of original power, restless activity, great energy and a natural-born revolutionary.

The early influence of philosophers of the fantastic neo-platonic natural philosophy of the Florentine Academy and its followers, had shaken his faith in the accepted Aristotelian and Galenic philosophy which was the basis of medical theory and medical teaching of the time. This revolt from the traditional dogmas, combined with manifestly acute powers of observation and an open mind for such medical or chemical practises or ideas as he met with in the course of his extensive experiences among all classes of people in many lands, resulted apparently in enabling him to surpass the conventionally restricted medical practise of his time in the successful treatment of many diseases. His reputation as a brilliant and able physician attracted early the notice of some of the noted scholars at Basel—and Paracelsus was called to that city as city physician and professor in the university. In his teaching he at once began opposing the conventional dogmas and the antiquated practise of medicine. The history of medicine and the testimony of learned critics of the period such as Erasmus, Agrippa, and Peter Ramus give ample evidence that the time was ripe for a reform in medicine. For centuries all initiative had been discouraged by the accepted infallibility of the traditional Greek and Arab authorities. The medical practise was based on analogical reasonings, and astrology, charms, incantations and exorcisms played an important part. To question the foundations of the medical theory or to introduce innova-

tions in medical practise was unpardonable heresy to the guild of physicians.

Paracelsus must be credited with the ability to appreciate the failings of the profession and with courage and ability with which he addressed himself to the task of breaking down the wall of inertia and tradition behind which the medical profession had entrenched itself. In this task he found but scant assistance from within the fold. On the contrary, he soon aroused the liveliest animosity and the most bitter opposition on the part of medical faculties. But opposition did not discourage him. His was the spirit of the propagandist and the fanatic, and antagonism and persecution but intensified the earnestness and the energy with which he labored for the spread of his revolutionary doctrines. That he might appeal to a wider constituency than the hostile academically trained profession, he followed the example of Martin Luther in discarding the use of the Latin language in lectures and writings, and wrote and spoke in his native German. This was also a flagrant offense against professional etiquette and helped to widen the breach between the medical schools and Paracelsus and his pupils and followers.

Irritated by the attacks of his colleagues, he retorted by publicly burning the Canon of Avicenna, as Luther had burned the papal bull, and similarly to show his contempt for the assumed infallibility of the ancient authorities of medicine.

The lines of attack of Paracelsus upon the medical doctrines of his time were mainly three. First: Not the authority of the ancient authors, but observation and experiment must serve as the basis of medical diagnosis and treatment. Second: The substances of the human body are chemically constituted, the processes of the body are chemical processes and hence chemistry must form one of the foundations of rational medicine. Third: The use of the complex mass of decoctions of rare and costly herbs which served as the basis of the Galenic physicians' practise was not founded on reason, but on superstition. In his view every medicinal plant or mineral has an essential principle or spirit and to find and purify these and to apply them to the cure of diseases is a worthy and important aim of chemistry.

Many interesting and valuable improvements in medical practise are attributed to Paracelsus, but it is not the early history of medicine that interests us here except as it is involved with the development of chemistry.

The works of Paracelsus were apparently written between 1526 and his death in 1541, and therefore were written before the publication of the work of the three chemists above mentioned. They are, as collected, a voluminous mass and of heterogeneous character, medical, surgical, philosophical, chemical and theological.

In harmony with his notions of the value of chemically prepared

medicines he introduced into the practise many remedies not authorized nor sanctioned by the medical schools. Preparations of antimony, iron, mercury and opium were prominent among these, and apparently were employed with success in his own practise. To the chemists he especially appealed to abandon the vain search for the making of gold and silver—"the threshing of empty straw"—and to devote their energy and skill to the preparation of new remedies, and to their application to medicine.

But few of the works of Paracelsus were printed during his lifetime. In several cases the reason for this can be directly traced to the opposition of the medical faculties and their influence upon the public censors or publishers. But he did not cease writing on that account, and some twenty years after his death there began the active publication of his manuscripts. Some of these were autograph manuscripts—others more or less complete copies, or lecture notes edited or expanded by former pupils—some of doubtful authenticity, and others known to be fabrications published by anonymous writers. It is still difficult in many cases to be certain as to the authenticity of some of the many treatises attributed to him. Their popularity and influence during the succeeding century was very great, as is evidenced by the fact that the Paracelsus bibliography by Sudhoff enumerates no less than 390 titles of printed publications up to 1658, when the last and best known Latin edition of his collected works made its appearance. Among these were four editions of his collected works in German and two in Latin.

Through the mass of writings of Paracelsus are scattered, rather than systematically gathered, the chemical facts and theories which comprise his contribution to chemical literature. Together they form a considerable body of chemical knowledge, descriptions of chemical processes and substances known in his time with much of speculative theory. There is no evidence that he added in any important way to the chemical knowledge of his time. Though the first announcement of some chemical facts appear in his writings, he makes no assumption of originality in their announcement, any more than do Agricola and Biringuccio in their works. It was rather by his evident familiarity with the chemistry of his time, and the novel and radical application of chemical preparations in the practise of medicine, that he challenged the attention of the chemists of his time. Here his influence was epoch-making. In the field of chemical theory he shows greater originality, and while much of his speculations are fantastic in the fashion of the philosophy of the time, yet in other directions he exerted important influence.

One very influential contribution to chemical theory, however, is to be attributed to Paracelsus. This was the theory of the three principles—the "tria prima." It will be remembered that the early alchemists had recognized the peculiar relation of sulphur to the occur-

rence and changes of the metals—the sulphur of the philosophers—and similarly with respect to arsenic and mercury. Upon these vague and variously formulated hypotheses Paracelsus founded his more consistent theory.

All matter was, according to Paracelsus, constituted of three principles, sulphur, mercury and salt. Sulphur, he explains, is that which burns—the principle which renders bodies in any degree combustible and yielding heat. Mercury was that principle of bodies which renders them liquid or volatile, which enables them to melt on heating or to pass off as a vapor by distillation or volatilization. Salt was the principle which resists the action of heat—the ash or the non-combustible and non-volatile constituents of matter. It will be observed that this is a generalization of the properties of substances based upon the observation of their behavior towards the various degrees of heat to which they were subjected in the customary processes of roasting, distillation, ignition or reduction (this word also we first find in Paracelsus).

The doctrine of the three principles of Paracelsus possessed that advantage over the Aristotelian elements—fire, water, earth, air—in that it was more closely related to experiment and experience and not so purely metaphysical. It could serve as a kind of working hypothesis to help understand the results of chemical experiment. The *tria prima* received early recognition in chemistry. The very celebrated work called the "Triumphal Chariot of Antimony," written about 1600 and passed off on the public as a translation of an early manuscript by an alleged Benedictine monk, Basil Valentine, adopted and helped to give a wider circulation to this theory. It became almost universally accepted by the chemists of the seventeenth century, and such popular text-books as those of the French chemists, Christopher Glaser and Nicholas Lemery, placed it at the foundation of chemical theory (the latter as late as 1713).

In the latter part of the seventeenth century, Becher introduced a variation of this theory, by placing, instead of sulphur, a terra pinguis, as the combustible constituent, fat or oil having, in so far as its combustibility is concerned, a similar behavior to sulphur—for mercury and salt he substituted a terra mercurialis (mercurial earth) and a terra lapidis (or stony earth),

This in itself was no advance, but Becher's pupil, Stahl, and his followers elaborated this sulphur of Paracelsus or terra pinguis of Becher into the idea of a more abstract heat substance, phlogiston, while the less useful hypotheses of the mercury and salt gradually disappeared.

In the eighteenth century under the influence of such able chemists as Scheele, Black, Cavendish and Priestley the phlogiston theory became the most inspiring theory to stimulate the observation and researches of chemists. Only at the close of the eighteenth century when the

phlogiston theory was no longer adequate to explain all known facts were the facts it attempted to explain re-interpreted by the genius of Lavoisier in terms of the modern theory of oxidation and reduction.

In considering the value and influence of all these now abandoned theories, we should keep in mind that the value of a theory in science at a particular epoch depends not so much upon its absolute truth or reality as upon the extent that it assists in classifying and accounting for observed facts and in stimulating to new observations or experiments.

It will be seen how the above theories are linked together and how each served for its own century and prepared the way for its successor. Nevertheless, the greatest service which Paracelsus contributed to the development of chemistry was in the influence which his teaching and his example and his widely published works exerted in battering down the wall of infallible dogma that for centuries had protected the doctrines of medicine from any important development from the side of its relation to chemistry. His unceasing criticism of the defects of the theory and practise of the ancient authorities, his trenchant arguments for a broader experimental basis for the science, his severe arraignments of the ignorance and venality of the physicians of his time; his ridicule and defiance of their sacred authorities, together with the constant reiterations of the knowledge of chemistry as essential to understanding the life processes in health and disease, exerted a powerful influence not indeed so much upon the university faculties or the physicians schooled in their doctrines as upon the younger and more progressive generation of students. Also his appeal to the chemists as such to find in the future of medicine a field of endeavor more promising of success than the as yet unrewarded efforts for the transmutation of the base metals into gold, found much following among those who were interested in the study of chemistry. If we recall that most of the scholarly trained chemists were also physicians, we can understand how this combination of medical and chemical aims advocated by Paracelsus found fertile soil among young physicians and medical students as among chemists of less conventional training.

That this is true is shown, not only by the tremendous vogue of his printed works, but also by the fierce contest which for a century split the medical profession of Europe into hostile and embittered factions of Paracelsists and anti-Paracelsists—adherents of the new chemical medicines and advocates of the older Galenic remedies.

While the greatest service of Paracelsus was to shatter confidence in dogmas revered for the sake of their authors' great names, the new doctrines which he set up to replace the dogmas he combated were, in many respects, as fantastic and unscientific as the earlier ones. Nevertheless, the shattering of the blind faith in traditional teachings, which gave to Paracelsus his popularity and following, necessarily operated also to prevent his new doctrines from becoming considered as sacred

or infallible. Free criticism and independent thought once aroused could not again be contented with blind adhesion to any unchanging system of doctrines.

Very naturally the period of chemical activity following the shattering of long-accepted dogmas was characterized by many wild and fantastic notions. Many of the most extravagant claims of alchemy and of marvelous medical nostrums are found in the literature of the latter part of the sixteenth and of the first half of the seventeenth century. But much was done, on the other hand, in developing chemical facts. Men like Van Helmont and Glauber, while retaining much of the mysticism and obscurity of Paracelsus and earlier chemists, yet contributed in no unimportant way to the constructive work of adding to established chemical facts as the result of their experiments, though indeed contributing little of permanent value to chemical theory or generalization. Chemists were generally either adherents of the Aristotelian elements, or of the three elements of Paracelsus, according as they belonged to the conservative or radical parties. Nevertheless, there was much independent speculation and theorizing, though rarely on a scientific basis. The new freedom found expression in extravagances of ignorance and superstition, in charlatanry and imposture, as well as in much earnest and valuable labor. But at all events, chemistry was now, at last, very much alive, and the mission of chemistry was at last recognized as of importance and dignity. Werner Rolfink, professor of anatomy, surgery, botany, medicine and chemistry at Marburg, is said to have been the first officially recognized professor of chemistry in Germany—A.D. 1629. A chair of chemistry was established early in the same century at the University of Paris, and a Scotch physician, William Davisson, was the first incumbent. In 1635 he published a text-book on chemistry for the use of his students, a work which passed through many editions.

The University of Leyden is credited with the first chemical laboratory at a European university, and the distinguished De la Boe Sylvius was the professor of the theory and practise of chemistry as well as of medicine. He was a strong adherent of the chemical medicines. Other early university laboratories were at Altorf, 1663, Stockholm, 1683.

Thus was beginning to be realized the ideal so confidently maintained though vaguely realized by Paracelsus, of exalting the study of chemistry and recognizing its importance in the development of medical science. How important the interrelation of these two sciences was to be in our day revealed, not even the imagination of Paracelsus could have dreamed.

As Paracelsus in the sixteenth century gave the first important impulse to the development of modern chemistry, so, in the middle of the seventeenth century, Sir Robert Boyle may be said to have inaugu-

rated a new epoch in chemistry by his remarkably sane and sound criticisms of the chemical thought and theories of the time. Boyle was a broadly and thoroughly trained scholar of the time, and prominent in many lines of activity. He was one of the founders of the Royal Society of England and at one time its president. He was also a man of wealth, but his main interest was in experimenting in chemistry and physics, and many notable observations stand to his credit. Every student of chemistry or physics knows of Boyle's law of gases.

It is not, however, by his experimental work—valuable as it was—that he exerted the greatest influence, but rather by his extended and frequent careful and scientific criticisms of the prevalent chemical theories, both the Aristotelian and Paracelsan theories, of the nature of substances and matter. Particularly by his work published in 1661 entitled "The Sceptical Chymist," in which, rather verbosely, but with great thoroughness and yet with great tolerance and patience, he submits the theories of the time to really constructive criticism. By a wealth of facts and experimental illustrations he demonstrates the purely metaphysical character of both the prevalent theories, and gradually develops the only consistent concept of an element which was possible for his time—namely, any substance which no experimental evidence could show to be reducible to simpler substances. He makes indeed, no attempt to say that any particular known substance is indeed an element in the sense of his characterization, though one might infer from his discussion that gold and silver were as well deserving of the title as any substances known to him, as he has never been able to obtain anything else from them or to know of any reliable experiments with such results. Unlike Paracelsus, or Glauber, or Van Helmont, or their imitators, Boyle was no dogmatist, being slow to assert and yet open-minded to any facts and very respectful to the opinions of others, though not in the least dominated by them.

The "Sceptical Chymist" of Boyle, as well as others of his writings, had a very wide circulation throughout the continent as well as in Great Britain, and his sane and persuasive reasoning, free from mysticism, and based on legitimate inferences from observed facts, made a great impression upon scientific men. While he offered no theory to replace the discredited Aristotelian and Paracelsan theories of the constitution of matter, he transferred the emphasis of chemical thought from *a priori* speculation to rational deductions from observed phenomena, and, though these might often be imperfect or mistaken, yet chemical reasoning was launched upon a course which could only lead to clearer understanding and to more soundly established theories.

The century following Boyle may be well characterized as the phlogistic period, because the representative chemists of that period were largely occupied in systematizing chemical actions with reference to that theory.

The fundamental notion of this theory was, as we have mentioned, a development from the combustible and heat-giving sulphur of Paracelsus to the notion of a heat substance, phlogiston, which constituted a part of all combustible or, as we should say, oxidizable substances. The phenomena of combustion or oxidation were in terms of this theory due to a loss of phlogiston—the phenomena of reduction to a gain of phlogiston. It is just to say of this theory that it proved a fertile and valuable hypothesis to the science of chemistry in developing a vast amount of excellent experimental work and of comprehensive generalizations. We have only to recall the names of Scheele, Priestley, Marggraf, Black and Cavendish to realize the class of chemists whose labors were influenced and stimulated by the adoption of this theory.

Two serious obstacles to continuous progress were, however, inherent in this theory. The supposed phlogiston could not be separated or isolated and weighed. It could not be known whether it had a positive weight in combination, or whether it could affect in any definite or determinable way the weight of other substances. It might even have the effect of buoyancy or of diminishing the weight of substances with which it was combined, and so long as such ideas were held the weights as given by the balance could not be depended upon to give the real quantitative relations of chemical reactions.

The second obstacle this theory offered to chemical development lay in the fact that so long as this theory was maintained no identification of substances as elements was possible. Boyle had given us a proper definition of an element, but so long as such oxidizable substances as phosphorus, sulphur, iron, zinc or carbon were considered as combinations of phlogiston with other substances (viz., their oxides) and so long as the products of combustion, such as we now know, as the oxides of phosphorus, sulphur, iron, etc., were considered as products of the loss of phlogiston, and therefore to that extent simpler or more nearly elementary than the combustibles from which they were produced, it is manifest that the elementary character of most of the known elements could not have been recognized. It required the insight of Lavoisier to discern the real nature of combustion and reduction, and to banish at last the element phlogiston from the weighable factors of chemical reactions.

But with this period of chemistry, the dawn of modern chemistry was past and the sun was shining brightly above the horizon.

THE FLORAL FEATURES OF CALIFORNIA

By Dr. LeRoy Abrams

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SHUT off from eastern North American by the high Sierra wall, that formidable barrier to the eastern and western migration of plant, as well as animal life, and possessing a climate unlike that of any other part of the continent, California has developed a flora that is unique. Indeed, isolation has been so complete that the California flora, with its host of peculiar or endemic species and even genera, displays many qualities characteristic of an insular flora, such as one might expect to find on a remote oceanic island. To the traveler familiar with the flora of the Mississippi Valley or of the Atlantic States, California plants seem as foreign as those of southern Europe. Species of such well-known genera as *Quercus*, *Prunus* and *Rhamnus* (the oak, the cherry and the buckthorn) are so unlike their eastern relatives in foliage and general aspect that their true relationship is revealed only on close scrutiny.

But if the Sierra wall with its snow-clad summits has been an effective barrier to the eastern and western migration of plants, it has been likewise effective as a pathway for the southern migration of northern plants. And the warm valleys and foothills that lie at its base have been similar pathways for the northern migration of southern types. We find, therefore, the California flora composed of three distinct elements, the Californian, the Boreal, and the Mexican.

The Californian element, as recently discovered fossils prove, was established before the Glacial Period, and through its preservation from the destructive ice sheet, California has been able to hand down such a priceless heritage as the sequoias, an all but extinct race that at one time flourished over North America, Europe and Asia, extending as far north as Greenland and Spitzbergen. With the sequoias have come down many other conifers, making the California coniferous forests the richest in the world.

The Boreal or northern element, pushed southward by the ice sheet of the Glacial Period, formed a belt on the California mountains below 5,000 to 8,000 feet, the perpetual snow line of the ice age. At the end of the period, the ice retreated upward and northward, followed by the boreal plants, with the result that we now have arctic and subarctic species stranded on mountain tops a thousand miles or more south of their general range.

The Mexican element has migrated, largely since the Glacial Period.

from the south through the desert and Great Basin regions following increased aridity. The great Mexican Plateau was the original home of most of the strictly American genera now found throughout arid and semiarid western America. On this plateau a drought-resisting flora existed in the Miocene age, when the greater part of the United States from the Atlantic to the Pacific was covered with a rich deciduous forest, comprising such trees as the beach, elm and magnolia—a type of flora that still persists in the southern Atlantic States.

The rôle played by climate in California has augmented that of isolation. Without its peculiarities and diversities the rich and varied California flora would never have been evolved. California climate is lauded the world over. Yet the term means little and is misleading as it carries the impression of uniform climate. Naturally within a state extending through more than nine degrees of latitude, 769 miles, one would expect to find considerable difference in the temperature of the northern and southern sections, with a corresponding difference in vegetation. But add to this range of latitude diversity of topography with its marked influence on rainfall, temperature and atmospheric humidity, and we have a complexity of climates and climatic influences that are astounding—literally scores of climates sufficiently distinct to influence profoundly the character of the vegetation.

Temperature, one of the most important factors governing plant distribution, ranges from the perpetual snow fields of the mountains to subtropical valleys where killing frosts are scarcely known. Bordering the snows of the high Sierra such boreal plants as the dwarf arctic willow, cassiope, bryanthus, primulas and fringed gentians, flourish, while in the subtropical sections, the lime, the olive and the pomegranate are grown, and even the more sensitive though less poetic banana and alligator pear. Everywhere the African pelargoniums, the "geranium" cherished by the eastern housewife and tenderly nurtured within her furnace-heated house, runs riot, growing into good-sized shrubs and frequently used for porch coverings or hedges. The castor bean, described in all botanical text-books as an annual, here becomes a tree living for years, and grown for ornament and shade. Between these two extremes, boreal and subtropical, are all the intermediate zones; the cool temperate, where rye, red currants and apples flourish, and the warm temperate with the almond, apricot and fig.

But great as is the range of temperature and its effect on vegetation, rainfall and atmospheric humidity are fully as varied and play even a more important rôle over a large part of the state in determining the character of the vegetation. The normal annual rainfall in certain localities of the northwest coast region runs nearly to one hundred inches. At San Diego, also on the coast, it is only a little over nine inches. On the deserts, lying east of the mountains which have robbed

the prevailing winds and storms of their moisture, the normal rainfall is seldom over five inches and often less than two.

With such a complex of climatic conditions it would be futile to attempt an account of the numerous plant associations or formations. We shall rather try to present some of the general features of the most important floral districts or belts.

The Coniferous Forests

California possesses the richest and most unique coniferous forests in the world. Nowhere is there the wealth of species and genera, nowhere such giant trees or interesting and rare types. Within the state there are thirteen genera and forty-eight species, twice the number found in the territory covered by Britton and Brown's "Illustrated Flora," an area over six times that of California. But it is not so much the variety of kinds that makes these forests famous as it is the grandeur of the individual trees, and the unique character or scarcity of the species.

The Giant Sequoias or Big Trees are world-renowned for their immense size and great age—the oldest and largest living beings. Here, in their Sierran fastness, these giants stand majestic, vigorous and sound to the heart—trees that were centuries old when Christ was on earth. In the words of their first warden, the venerable Galen Clark,

> their majestic graceful beauty is unequalled. . . . The bright cinnamon color of their immense fluted trunks, in strong contrast to the green foliage and dark hues of the surrounding forest, make them all the more conspicuous and impressive. In their sublime presence a man is filled with a sense of awe and veneration as if treading on hallowed ground.

They are distributed along the western slopes of the Sierra Nevada at middle elevations for a distance of about two hundred and fifty miles. Toward the southern end of their range extensive forests are formed and reproduce freely; but north of Kings River the groves are small and isolated, comprising middle-aged or mature trees with few or no seedlings. These isolated groves are thought to represent the original patches which escaped the destructive onslaught of the ice age. The average height of the large specimens is about two hundred and seventy-five feet, although trees three hundred and twenty-five feet have been measured. The diameter of the trunk averages about twenty feet, but a few trees attain thirty, and the General Grant is said to be forty feet at the much-enlarged base.

The Mariposa Grove and the smaller Tuolumne and Merced groves are within the Yosemite National Park. In addition to these, two other parks have been established by the Federal government for the preservation of the giant sequoia, the General Grant National Park, situated in the Kings River forest and the Sequoia National Park, in the Kaweah River forest.

Inland Border of the Fog and Redwood Belts, Photographed by Robinson and Crandall.

Associated with the giant sequoias are to be found some of the best specimens of other Sierran conifers. Of these the sugar pine is the most magnificent. It is the king of pines. It attains a height of two hundred to two hundred and twenty feet, with a bole eight to twelve feet in diameter and often eighty feet to the first limb. The huge cones eighteen to twenty-six inches long hanging pendent from the tips of the widely spreading branches are a striking feature that marks the sugar pine as far as the eye can see.

In the redwood (*Sequoia sempervirens*) the giant sequoia (*Sequoia gigantea*) has a strong rival for first honors. The redwood is the highest known tree, the giant sequoia the greatest in diameter. Comparatively they stand about three hundred and fifty to three hundred and twenty-five feet in height, and twenty-two to thirty feet in diameter. The redwood is more abundant than the giant sequoia, and in the Humboldt forests it forms magnificent stands of timber from which over one million feet of lumber have been cut from one acre.

The distribution of the redwood is an excellent illustration of the delicate balance held between vegetation and climatic environment. It forms a distinct belt along the coast ranges of central and northern California, never extending inland more than twenty or thirty miles and conforming with striking significance to the coastal fog belt. The heavy summer fogs that frequent the coast ranges of central and northern California lower the temperature and increase the atmospheric humidity. Furthermore, the minute fog particles are collected on the forest trees and precipitated to the ground. The writer has tramped through fog in midsummer chilled to the marrow, with the trail muddy and slippery wherever it passed beneath a tree. Indeed, so great was the precipitation of the fog by trees that little rivulets formed and ran several yards down the mountain trail. Fifteen minutes' walk away the hot August sun was shining on a road inches thick in dust. Here were climatic differences as great as those of England and Spain.

Associated with the redwoods, but of more extended range are a number of other trees of special interest. The tanbark oak (*Pasania densiflora*) is the only representative in North America of that large Asiatic genus. Its acorns resemble those of an oak, but the staminate flowers are in dense erect catkins as in the chestnut, and with the same disagreeable odor. The California laurel, the only member of the genus *Umbellularia*, is a beautiful evergreen tree with smooth dark green lance-shaped leaves that emit the odor of bay. The madroñe (*Arbutus menziesii*), with its smooth polished trunks of a rich mahogany color, is one of the most striking trees in the California forests. It has attractive foliage of large, smooth, glossy, oval leaves, and bears open clusters of deep red berries that persist until Christmas.

In addition to the great forests of the Sierra Nevada and the red-

wood forests of the northern coast region, there are, usually in remote isolated spots, a number of other conifers especially interesting on account of their extreme rarity. All these species, which are far more local and rare than the giant sequoia, are situated in the coastal region. They are supposed to represent an ancient flora that existed here when the coast ranges formed an archipelago some distance off the western shore of the continent.

The Torrey pine is the rarest pine in the world. It is found only in two small groves of scattered trees, one a few miles north of San Diego, and the other on the eastern end of Santa Rosa Island. San Diego has wisely acquired the mainland grove and established a park in order that these trees might be preserved.

The Santa Lucia fir inhabits the Santa Lucia Mountains, an isolated range lying along the coast between Monterey and San Luis Obispo. This fir is found nowhere else, and is distinct from all other firs in its sharp-pointed leaves and bristly cones. It is within the Santa Lucia National Forest and is therefore assured protection.

Both the Monterey cypress and the Monterey pine are found on the Monterey Peninsula. The pine forms a forest over a large part of the peninsula and extends down the coast for fifteen to twenty miles. There is also a grove on the coast of San Luis Obispo County and another a few miles north of Santa Cruz. The cypress is confined to two small groves situated on the two promontories that mark the boundary of Carmel Bay, just south of Monterey. Here, perched on the high cliffs overhanging the Pacific and buffeted by winds and storms into picturesque, often grotesque attitude, they add a Japanese touch to the charms of this coast, famed as the most beautiful spot on the Pacific. We are constrained to say that both of these groves are under private control. Cypress Point, the more accessible of the two, is in the hands of a self-styled "Improvement Company," and as we write word comes that it is to be surveyed into lots and thrown on the market. May public-spirited citizens do their utmost to acquire and preserve this unique grove! Surely it will be to our everlasting shame if California permits the destiny of these, the rarest of all trees, to depend upon the whims of summer cottagers.

Foothills and Valleys

Much of the peculiar charm of California lies in her rolling foothills and broad fertile valleys, purple-rimmed by mountains. Here are great stretches of the beautiful valley oak, with its massive spreading crown sometimes nearly one hundred feet across. To quote Dr. Sargent, the best known authority on American trees:

> No other region in the world presents anything to compare with its park-like beauty, the nobility of the individual trees, or the charm of the long vistas stretching beneath them.

It is in the valleys and foothills that the typical California flora is seen in its full glory. Here poppies and buttercups, creamcups, tidy tips, yellow pansies, sun cups, yellow forget-me-nots, berries and bush mustard throw a gorgeous mozaic of mingled yellows over the coast meadows. In the open foothills, fields covered with splendid splashes of the wonderful gold of the poppy and the deep blue of the lupine, broken in spots by the gray green of the oak, spread out like a huge impressionistic canvas. On gentle slopes of sandy loam, escobita, cousin of the gaudy Indian paint brush, stretches out into a velvety carpet of old rose.

Typical also of the California flowers are the many varieties of bulbous plants curiously adapted to the California climate by their deep-seated bulbs that lie dormant through the long dry season, sending up their foliage leaves in early spring and their flower-stalks at the end of the rainy season. In the open fields and country roadsides the mariposa tulips, coming after the showy spring annuals, display large open cup-shaped flowers, delicately painted as a butterfly's wing. Brodiæas, some with open, others with close clusters of blue hyacinth-like flowers, greet one everywhere. Mission bells, mysteriously invisible, stand solitary tall and erect in the open woods, delighting their discoverer with drooping bell-shaped flowers mottled with bronze and green. Fairy lanterns, exquisite little plants of graceful form and delicate coloring, grow half concealed among the grasses of the open woods and rock ledges.

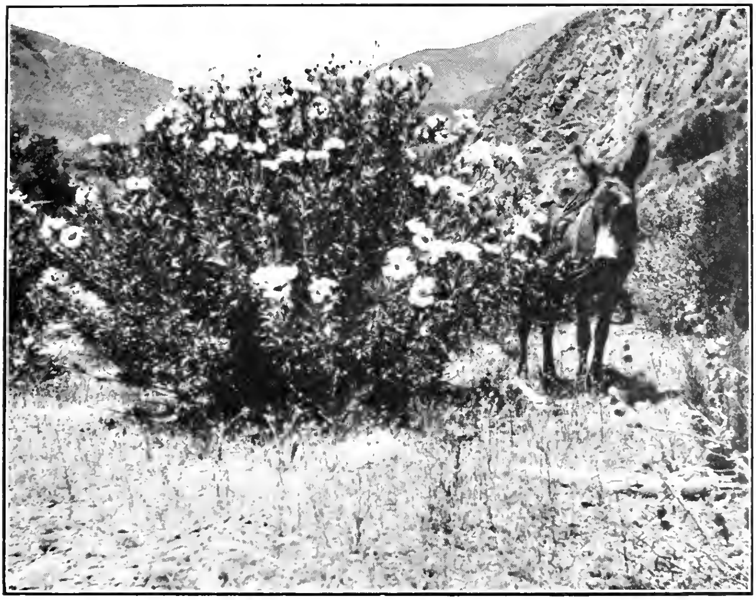
The advent of the white man has greatly changed the aspect of the vegetation in the valleys and foothills. Not only have vast fields of showy annuals, chaparral and noble oaks given way to orchards, vineyards and grain fields, but many of the open, untilled foothills are now covered with wild oat, bur-clover or filaree, southern Europeans, brought over by the Spanish padres and spread broadcast by nomadic bands of sheep, which at the same time wiped out forever many a delicate native annual.

The Chaparral

On dry gravelly hillsides, especially on southern exposures, and in the valleys where the soil is light and the water-table below the reach of roots, drought-resisting shrubs abound, forming dense, impenetrable thickets known as chaparral. These shrubs are evergreens with short, stiff, often spinescent branches and small, thick, leathery leaves of a dull gray or olive green. The level mass takes on a somber monotonous tone. But in blossom time, manzanitas with their tiny urn-shaped flowers of a delicate pink, lilacs forming masses of blue, lavender or white, garrya, with its long, pendant, soft gray catkins that have won it the name of "silk-tassel tree," the ever-present chamise, a peculiar rosaceous shrub with the foliage of the heath and spiræa-like clusters

of small white flowers, the chaparral pea, mountain mahogany, bush poppy and yerba santa, all lend a charm that compensates for the long periods of gray monotony.

The preponderance of shrubs is a striking characteristic of California. One familiar with the shrubs of the eastern states will discover many surprises among the California varieties. To be sure, he will find many familiar genera, such as roses, currants and snowberries, but many strangers as well, such as the shrubby poppies, phloxes, mallows, monkey-flower, and even senecio. His solitary bear berry, uva-ursi, is here represented by about twenty species and New Jersey tea by over



The Matilija Poppy in Early June, photographed by the writer.

thirty, many of which are very attractive in bloom and appropriately named California lilac.

In southern California the wild buckwheat, the laurel-leaved sumac and the black and white sage are prominent along the lower edge of the chaparral. The buckwheat and sages are bee plants par excellence, and produce tons of clear white honey. The Spanish-bayonet, a member of the yucca family, is widely distributed through the chaparral. Most of the year it is merely a tuft of dagger-like leaves, but in May and June each tuft sends up a straight flower-stalk eight to twelve feet high, bearing a huge pillar-like mass of creamy white flowers that may be seen for several miles. On canyon floors one will occasionally meet the matilija poppy. This is California's most gorgeous flower. It grows in round clumps eight to ten feet high, bearing a profusion of delicate

crepe-like flowers, five to eight inches across, pure white in color with a rounded mass of yellow stamens in the center.

The Deserts

To transcontinental travelers the deserts are bleak, forbidding wastes, the very antithesis of life, and are passed with a shudder. But to him who follows their shifting trails with burro and pack saddle they open up a new world; animals, plants and the very rocks wholly unlike those of his well-trodden paths through fields and meadows. He may travel for days over the desert without meeting a familiar plant, no conifers, no oak, nor rose, no buttercups or violets. Plants, instead of spreading out broad green leaves to the friendly sunshine, protect themselves from the withering rays of a burning sun by casting off their leaves and forcing their twigs and branches to carry on their work, or by reducing the leaves in size and covering them either with wax, as does the creosote-bush, or with a dense layer of impervious cuticle, as does the desert holly, or with a gray mat of soft down, as do some of the daleas. Others, as the cacti, store up water in their thickened fleshy stems. Still others, members of the gourd family, develop enormous roots for water storage. Pondering on the significance of all these strange types, the wonderful adaptations, the development and modification of structures to meet these severe tests of endurance, one stands amazed at the powers of nature, realizing as never before the vital force of climatic environment.

Low, straggly shrubs of subdued tone and thorny cacti are the common plants of the desert. Of these the most universal is the creosote-bush with its waxy leaves, bright yellow flowers and all-pervading odor. Along living streams grow willows and cottonwoods, but desert trees are few in number. Where a little moisture is permanently retained, mesquit, palo verde and ironwood may be found. In the Mojave Desert the most striking feature is the yucca, which forms weird, fantastic groves scattered orchard-like over many square miles, the Joshua tree of the early Mormon settlers. On the western rim of the Colorado Desert, fringing the base of the southern California mountains, are several groves of the desert palm. An especially fine group is in Palm Cañon, splendid trees with straight, unbranched trunks eighty to one hundred feet high, crowned by great tufts of spreading fan-shaped leaves and clothed sometimes nearly to the base with withered leaves that lie pendant along the sides in great thatch-like masses. Here is a veritable Saharan oasis, and there eight miles away and ten thousand feet above, stands the summit of San Jacinto, harboring typical arctic plants around its lingering patches of snow.

Such are the contrasts of California.

A HISTORY OF FIJI. II

By ALFRED GOLDSBOROUGH MAYER
THE CARNEGIE INSTITUTION OF WASHINGTON

UPON the death of old Tanoa, his son Thakombau (evil to Mbau) became Vunivalu. He was an ambitious, energetic, crafty and intelligent man, but the problems of government were becoming yearly more complex in Fiji.

Missionaries had entered the group in 1835, and although Tanoa did not permit them to live in Mbau or to attempt to make converts of his subjects, other chiefs welcomed them, for they brought valuable presents and increased the importance of those among whom they lived. Gradually other white men had come to Fiji. At first mere degenerates or deserters from vessels who lived as did the natives themselves, but afterwards men of more ambition and intelligence gathered to the shores of these distant islands, and assumed a leading part in affairs. The missionary influence was beginning to be felt, for converts were being made among the lower orders of the population, and the power of the native priests, and with it that of the chiefs was weakening.

Vainly did Thakombau rail against the advance of civilization, for the hated power of the Mbau chief, founded as it was upon terrorism, was doomed. One after another defeats came to the war parties of Thakombau, and so reduced was he at last that, the missionaries being the sole power left to whom he could appeal for aid, he was forced in 1854 to profess Christianity, and cannibal feasts were known no more at Mbau. It was a great triumph for the missionaries, the result of nineteen years of unremitting toil amid constant dangers and surroundings unspeakable in horror.

That Thakombau's conversion was forced upon him as a matter of expediency is evident, for in a speech he called upon the gods of Fiji, saying that he still respected them as of old, but that the time had come when he must add the white man's god to those of his ancestors.

In the days of his power he had owned a fleet of more than a hundred war canoes, manned by a thousand warriors. 15,000 subjects acknowledged him as king, and in addition half of Fiji paid him tribute or admitted his supremacy, and he had boasted that the cannibal ovens of Mbau never grew cold. He had more than fifty wives, and he himself knew not how many children, and when but a child he had wantonly murdered one of his playmates; yet he had but to declare himself a Christian and hundreds of his subjects followed the chief's example

as Fijian custom demanded. Indeed, even to-day whenever a high chief stumbles and falls all in his neighborhood must tumble like checkers in a row, and, if he takes medicine, his subjects clamor for some of the same sort.

We must not assume that all or even that most of the Fijians were hypocrites in thus following their chief. For years the zealous spirit of the missionaries had been at work among them and they had gained the hearts of many of the poor and downtrodden, especially of the women, upon whom the tyranny of savage days fell with a heavy hand. It was the high chief and the warrior classes who had most to lose through the levelling democracy of Christianity which denied their divine right to rule through tabu, abolished their polygamy, discouraged war, prohibited cannibalism and in every way lessened their authority and rendered ridiculous the proud traditions of their caste. While the high chief remained unconverted, the missionary's lot was happy in that he well could be the kind and simple friend of the distressed and the brotherly adviser of the troubled, but with the conversion his temporal power became paramount, for it was impossible for him to escape the difficult double rôle of leader in secular as well as religious affairs, and thus the simple-minded lover of mankind was suddenly exalted into the position of the vicar of the terrible god of the white man whose favor was hard to win and whose punishments were eternal.

It is but fair to the missionaries to recognize that their temporal power was at the outset forced upon them, and that the mistakes which they have at times fallen into are those which overshadow the spiritual function of the clergy in all states wherein the government has fallen under the domination of the priesthood.

It was indeed fortunate for Fiji that the missionaries had been obliged to labor for nineteen long and almost hopeless years, and to endeavor in every way to understand and endear themselves to the people before any of the important chiefs had yielded to their teaching.

Everywhere in the Pacific where missionary success was quickly and easily attained, results more or less disastrous to the natives had followed. Despite many notable and glorious exceptions such as Chalmers of Papua, the old type of missionary was too often predisposed to regard all customs not his own as "heathen," hence pernicious. Thus if his success was immediate, as in Hawaii, his well-meant zeal impelled him too quickly to overthrow old customs and at once to force upon his converts a semblance of the habits of his own stratum of European society.

In this connection it should, however, be said that the blame for most of the bigotry, which has been all too evident, especially in former times, should fall but lightly if at all upon the field worker who, living among the natives, comes to love them as his friends and at least deals with

them as individuals; but the fault lies chiefly with the home boards, who, not realizing the paramount importance of local conditions in treating with primitive peoples, have attempted to enforce almost the same set of regulations from Greenland's icy mountains to Africa's coral strand.

The missionary, whether he would or no, is forbidden to conduct marriages between heathen and Christians, and too often one party to the contract must enter upon it with a lie upon his or her lips. The hypocrisy and espionage which results from sharing with the informer, or the chief, the fines derived from those who smoke, or swear, or work upon a Sunday, may well be imagined, and moreover, altogether too large a share of the earned wealth of the natives is demanded from them, the revenues of the church in certain groups being decidedly larger than the taxes collected by the civil government.

Yet let us not blind ourselves to an appreciation of the fundamental good the missions have accomplished, for whether Christianity be true or false, the natives must live under the rule of a people actuated by its motives and its faith, and are thus through its acquisition inestimably better fitted to resist the evil that preys upon them with the advent of "civilization."

In Fiji, however, the natives had become thoroughly known to the missionaries before the great conversion of 1854, and many old customs were thus permitted to remain which would have been suppressed had the missionary, and the political *party* which inevitably springs up around him, came more quickly into power.

The *power* of the missionary, after the great chiefs cast in their lot with him, is indeed terrible for good or evil, and in Tonga and later in Fiji he connived at the arming of the natives in order to *conquer* "converts." As the struggling priest of a great religion the missionary inspires all respect, but as the crafty politician or bigoted inquisitor his actions become correspondingly reprehensible. Too often in those early days of missionary endeavor he seemed satisfied with a mere semblance of order and religion for this was the period in which faith rather than good works was deemed essential. To the natives he too often remained one of a foreign race—a wizard, terrible, mysterious and implacable. Happily, a change has come over the thought of the world, and the conditions we describe are not those of to-day.

Henceforth Thakombau was to remain nominally king in Fiji, but the real power was vested in the white men who had settled upon his shores. He had escaped the retribution of native revenge only to struggle hopelessly in the net of commercialism and diplomacy. It was a sad and disappointing period between the time of the conversion in 1854 and the annexation to Great Britain in 1874. Soon after Thakom-

bau "lotued"[3] in 1854, a powerful faction in Mbau rebelled and fled to Rewa where they arrayed themselves under the banner of the great chief Ratu Quara or Tui Dreketi (the Hungry Woman or the Long Fellow), a famous warrior and an implacable enemy of Thakombau who threatened to destroy Mbau and to kill and eat its king in revenge for the burning of Rewa in 1847. At one time only a single Tongan and a missionary guarded Thakombau in his house at Mbau, but, at this critical juncture, an American ship under Captain Dunn arrived and, aided by the missionaries, Thakombau and his party were enabled to purchase guns and ammunition. Rewa might still have conquered, however, had it not been that Ratu Quara died of dysentery in January, 1855.

Indeed, as the Reverend Mr. Waterhouse states, the people of Mbau grew to hate Christianity after Thakombau had professed it to be his religion. The Fijians had a highly developed system of constitutional government, which varied somewhat with the locality, but was nowhere an absolute despotism. In fact the influence of unprincipled white men and the introduction of firearms led to conquests which had done more to exalt the power of a few chiefs and to develop the worst excrescences of the social and religious system of Fiji than had any other factor.

At Mbau there were two high chiefs, the head priest of Roko Tui (the reverenced king) who was above all in rank and was held in religious veneration but took no part in war or political affairs; and the Vunivalu (root of war), the executive head of the tribe. Upon the death of the Vunivalu, his successor was elected from among his relatives by the land-owners and chiefs of the tribe, and should he fail to carry out their policy they refused to provide him with food.

After white men came and the lust for conquest overpowered all else at Mbau, their ancestral veneration for the Roko Tui declined, and the Vunivalu became correspondingly more powerful. Thus Thakombau was not the Mikado but the Tycoon of his people.

But to return to the historic narrative: King George Tubou of Tonga, the most powerful Christian convert in the Pacific, came to the aid of Thakombau in 1855, and for the moment reestablished his supremacy, but at the same time he acquired a knowledge of Thakombau's weakness, and became convinced that a Tongan conquest of Fiji was possible.

For generations the Tongans had been in the habit of sailing to Lakemba, Kambara, and other islands of the Lau group in Fiji, where the forests afforded large trees for the making of canoes. A year or more would be employed in canoe building, and thus the newcomers had

[3] Assumed the waist-cloth which the missionaries obliged all converts to wear.

learned Fijian customs and acquired an interest in the political affairs of the islands. Finally they began to overrun and conquer the Fijians and were the cause of much disorder and distress.

In about 1848 a powerful rebellion headed by Maafu the cousin of the Christian king broke out in Tonga, but was suppressed by George Tubou. Maafu, its leader, was exiled to Fiji and it was intimated to him that if he desired a kingdom it was his to conquer.

Of the highest Tongan birth, young, ambitious, of superb physique, energetic and in every sense a leader among men of action, Maafu came to Fiji and at once became the ruler of all Tongans in the group.

His policy was to assist the weaker Fijian chiefs at war with stronger enemies, and then the combined Tongan and Fijian army having been victorious, he would turn upon his erstwhile allies and overpower them. Thus he gained a foothold at Vanua Mbalavu and from this as a base he proceeded to conquer the Fijis. As Seeman says in his account of his Government Mission to Fiji:

> Where Maafu and his hords had been it was as if a host of locusts had descended.

Famine and poverty stalked in his wake, yet wherever he went there was a Tongan "teacher" by his side; and, as Seeman says,

> the Wesleyan missionaries were kept quiet by Maafu making it the first condition in arranging articles of peace that the conquered should renounce heathenism and become Christians.

There is a strange silence in missionary accounts respecting Maafu, for not once does his name appear in Calvert's "Missionary Labors among the Cannibals" published in 1870, yet he added hundreds of "converts" to their flocks, and the Tongans and missionaries remained upon the best of terms; and only after the treacherous and brutal torture and massacre of prisoners at Natakala[4] and Naduri were the missionaries forced by outraged public opinion to wash their hands of Maafu and join weakly in the protest against Tongan cruelty. It seems almost incomprehensible that this sad and revolting abuse of power should have been exhibited by the missionaries in the part they took in conniving at native warfare in Tonga Tahiti, and Fiji in order that their reports to the home mission might "glow with the glorious story of conversions."

By 1858 there were but two great chiefs left in Fiji, Maafu and Thakombau, and the two powers were face to face. Doubtless the missionaries would have had their own way more readily with Maafu, for when they had suggested to Thakombau the abolition of the old system and the establishment of a "constitutional monarchy," he had

[4] See William T. Pritchard, 1866; Polynesian reminiscences, pp. 225–234. London.

answered "I was born a chief and a chief I will die." Nevertheless he was finally forced into yielding to the demands of the white men. Thus Maafu "the Christian" would doubtless have conquered Mbau and become king of all Fiji had not Thakombau in 1858 signed a deed of cession granting his possessions to Great Britain. The British consul, William Pritchard, Esq., and a warship came to his aid, and Maafu was checked; and although the negotiations with England came to nought, the increasing immigration of Europeans to Fiji made native warfare more and more infrequent. Maafu had to content himself with only a partial realization of his ambition and in 1882 he died a disappointed man. Had he commenced his operations five years sooner, he would have become the conqueror of Fiji. It was the hand of Great Britain, not that of the missionaries, that had checked his blood stained career.

The affair which caused Thakombau most serious trouble appears to have been one of those extortions which have been so frequently perpetrated by a "civilized" upon a simple people. On July 4, 1849, the residence of a whiter trader named Williams, then serving as United States consul in Fiji, was burned and the natives stole some of the furniture and stores while the house was in flames. Thakombau does not appear to have been personally responsible for the firing of the house, but the natives of Mbau in which the incident occurred were subject to him, and Williams demanded from Thakombau about $3,000 as indemnity. Upon the king's refusing to pay, the consul's demands were gradually increased and other claimants appeared, so that finally, having secured the cooperation of the United States government, the sum of $45,000 was demanded. Utterly unable to meet this "indemnity," harassed at home, and threatened from abroad, it seemed to simple Thakombau an intervention of Providenece when certain money-lenders from Australia offered to pay the claim of the United States in consideration of the deeding to them of 200,000 acres of the best land in Fiji. It may well be imagined that only for a brief moment was his kingly head allowed to rest in peace. Poor Thakombau, and with him all Fiji, had indeed fallen "into the hands of the Jews," and it was a happy moment when, on October 10, 1874, he signed a document which read, "We, King of Fiji, together with other high chiefs of Fiji, hereby give our country, Fiji, unreservedy to her Britannic Majesty, Queen of Great Britain and Ireland. And we trust and repose fully in her that she will rule Fiji justly and affectionately, that we may continue to live in peace and prosperity." Never was the confidence of a poor and degraded people better requited by a rich and civilized one, for a strong, and generous hand had come to rule in Fiji and the light of a happier day dawned upon the oppressed. Sir Arthur Gordon (afterwards Lord Stanmore) was the first British governor. He had

witnessed the cruelties of the disastrous native war in New Zealand, and knew full well how difficult it is to graft a European civilization upon a Polynesian stock. Fortunately there were high-principled men to whom he could turn for advice, and he did well in seeking the councils of Mr. John Thurston, long a resident in Fiji.

The annual poll tax of £1 per man and 4s. per woman which Thakombau's government had imposed was working ruin and death in Fiji. It was impossible for the natives to earn so large a sum, but the white planters eagerly paid the taxes and then "indentured" the wretched creatures, who were forced to work upon the plantations of their white masters at a wage so low that they toiled for 280 days in the year simply to repay the tax which the planter had paid to the government. Thus were the Fijians being entrapped into a bitter and unnatural bondage more merciless than the orgies of the worst period of cannibal days.

But Sir Arthur Gordon and Mr. Thurston soon tore loose the shackles of the slaves, despite the angry protests and threats of the whites in Fiji. Their plan was that each district be obliged to maintain a garden of copra, cotton, candle-nuts, tobacco, coffee or other produce, or to supplement this by the manufacture of mats or other articles of trade, and at the end of each year the products were to be sold under government supervision to the highest bidder and any money received over and above that of the district tax was to be returned to the district itself and divided among the taxpayers. This simple plan, which closely accords with their ancient manner of raising tribute, has encouraged industry among the natives, shielded them from the avarice of traders, secured to them their lands, and each year produced a sum considerably in excess of the taxes.[5]

Excellent as this plan was, it remained deficient in one important respect, for the government made no effort to establish manual-training schools wherein old crafts might be improved and new ones developed. Education in Fiji has been confined to religion and the "three R's," and inspiring as it is to witness the son of a cannibal extracting cube roots and solving quadratic equations, one inclines to the opinion that the prodigy's future life would be better assured of a career of useful service to the world and of happiness to himself had he been taught to be a good carpenter, mason, farmer or decorator. It is certainly unfortunate that, having ingeniously created a market for the products of Fijian labor, the English failed to improve the earning capacity of the natives, thus losing an unique opportunity to stimulate an interest in the useful arts that might soon have obliterated the apathy of the downcast race.

[5] Recently some of the districts have been permitted, subject to consent of the Governor, to pay their tax in money.

Mr. Thurston, the originator of the new system of taxation, had come to Fiji as a common sailor before the mast, but he lived to be Governor of Fiji from 1888 to 1896, and died as Sir John Thurston, universally beloved by the race for whose uplifting he had contended so courageously and well, and thus in Fiji there live to-day the happiest, the most law-abiding and potentially the most nearly civilized natives in the Pacific. It is one of the very few instances wherein a powerful and enlightened race have studied and toiled through many unrequited years to lift to a happier level a poor and barbarous people.

There is no longer in Fiji that painful contrast of which Wilkes complained between the beauty of the island scenery and the character of the inhabitants, for consistently in all respects the archipelago is now one of the fairest spots within the tropic world.

Nowhere in the Pacific did old customs change more slowly under European rule than in Fiji, for it has been the consistent policy of the British government to leave unaltered all that was good in the manners of old days.

The villages are almost as they were before the white man came, only the log stockades and the encircling moats have disappeared during the long years of peace, and the houses are no longer perched upon the summits of ærie cliffs, but now cluster along the river-banks or under the cocoa palms of the seashore. The high-peaked Mbures or temples, once such a picturesque feature, have fallen into decay with the advent of Christianity, although one thinks they might well have been preserved, enlarged and converted into Christian churches, for the tasteful sennit patterns which adorned their beams and rafters would have made the chapel the most attractive house in the village instead of being, as it too often is, a cheerless barn-like structure, ill-proportioned without and barren within.

The better types of native houses are set upon artificial embankments of stones and earth, sometimes twenty feet high, as in the valley of the Rewa River, where floods may be expected. The framework is of tree fern or cocoanut logs, ingeniously lashed together, and the sides and roof are covered with a thick thatch of wild cane, or cocoanut leaves spread over ferns. The roof is quite thin at the peak, but is fully a foot and a half thick at the eaves, where it projects slightly, and is cut off squarely, presenting a very neat appearance. The ground-plan of the house is usually rectangular, not oval at its ends, as in Tahiti, and the peaked roof has a long ridge-pole which projects several feet beyond the eaves and, if the residence be that of a chief, is thickly studded with white *Cypræa* cowrie shells, and sometimes other cowrie shells are strung upon ropes of cocoanut fiber sennit and hung pendant from the projecting ridge-pole. There are no windows, but several openings serve as doors and may in time of rain be closed with mats.

The floor is covered with several layers of pendamu mats, and a raised dais at one end of the single room serves as a bed and may be screened by mosquito-proof curtains of masi (tapa). A rectangular earth-covered depression serves for the fireplace and the smoke escapes as best it may, the smoldering embers imparting always a pleasant aroma to the air.

In speaking of everything Fijian, we must remember that the peoples of the Ra, or western islands of the Archipelago, and of the mountains, are of purer Papuan stock and are more primitive than those of the Vititonga race of the Lau group and the eastern coasts of the large island. Accordingly, the houses differ in different places, being smaller, more crudely and flimsily made among the Papuan than among the Vititonga tribes. Also in the western parts of the large islands and in the Ra islands, the chiefs are not so highly respected as among tribes whose blood has been mingled with the aristocratic Polynesian. At Mbau, the Roko Tui was almost god-like in native estimation, whereas in the mountains of Viti Levu the chief was only the leading councilor of the tribe, and labored in the fields in common with his subjects. Indeed the Mbau chiefs looked down upon those of the western part of Viti Levu, calling them Kai-si (peasants).

If the house were that of a high chief, as at Mbau or Rewa, the roof-beams were wrapped with interlacing strands of cocoanut fiber sennit, displaying a pattern in rich browns, black and yellow, so pleasingly contrasted that one is forced to regret that work of such high artistic merit should be suffered to remain in a house as inflammable as a haystack. Yet these houses withstand a hurricane far better than do the hideous corrugated-iron-roofed structures of Europeans.

Several old wooden basins, yaqona bowls, are hung upon the wall, their naturally dark wood coated with pearly blue where many a brewing of the drink has stained them. Carved war-clubs and long elaborately decorated spears may be seen suspended from the beams, and as the eye becomes accustomed to the dim light one beholds such treasures as a sperm whale's tooth strung as were old-fashioned powder horns upon a rope of cocoanut fiber and polished through repeated rubbings with cocoanut oil until its surface is as brown as tinted meerschaum. A few fly-brushes, pandamus fans for awakening the fire, a huge ceremonial war-fan of palm-leaf, some wooden food bowls, and crude cooking pots of fire-baked clay, and a clock that never goes, complete the list of the furniture. Yet one thing of painful memory one would fain have overlooked—the universal pillow. This consists of a block of wood or stick of bamboo supported upon legs so that it stands horizontally four or five inches above the floor. In old days when the hair was most elaborately dressed and trained into a huge mop, this pillow was doubtless a necessity, but in this shaven and shorn period of

Chrisianity such an instrument of torture might well be dispensed with, although by the native it is still regarded as the acme of luxury.

Housekeeping is simple in happy Fiji, where all is charmingly clean, and thick layers of soft mats invite repose upon the floor. Indeed the natives sleep much by day, for at night there is apt to be a "meke," wherein the maidens of the village, adorned in garlands of flowers and well polished with cocoanut oil, sing far into the small hours, keeping time to their chants by graceful gestures. This, together with the dull beating of the wooden drum, drives all hope of sleep away, but it is to be preferred to the "silent" nights when rats and mice scamper ceaselessly over the floor, contesting their supremacy with an occasional centipede or land crab. Yes, one must live a life of leisure and sleep by day in Fiji.

The largest edifice in the village is called the "stranger's house" for it is here that guests are entertained and fed by the community under orders from the chief. At Mbau the old stranger's house has stood for generations, dating far back into cannibal times, and within its walls the first Christian service was held in 1854. It is about 125 feet long and 40 feet wide, being exceeded in length only by the stranger's house at Rewa.

Carpenters are a highly respected caste in Fiji, and canoe and house building are occupations fit to engage the activities of chiefs. When one desires a house, a whale's tooth or other suitable gift should be presented to the chief, who then engages the carpenters, who in turn may command the services of more than two hundred assistants, all of whom labor so efficiently that in from one to three weeks the house is erected and ready for company. In the South Seas things are done in communal fashion and village labors, such as house building, canoe making, and the gathering of crops are occasions for songs and dances and all manner of merriment and feasting.

There is much of interest in Mbau, for although the ovens have long ago grown cold, yet the great foundation stones of the old temple of the war god (Na Vatani Tawake) still remain in the center of the village, and in 1898 one could still see the sacred tree upon whose boughs were hung the genital organs of victims who had been sacrificed to the Fijian Mars.

Close by the side of the foundation of the old temple a sharp-edged column of basalt is set upright within the ground. This is the stone to which victims were dragged by their arms and upon which their heads were dashed. Fragments of human teeth might still be found by digging at the base of this stone, and in many a house in Mbau there were sail needles made from leg-bones of the victims. There was another execution stone which was axe-shaped and thrust upright into the ground near the foot of the hill; but this now serves as the baptismal font, and is set within the church. The ovens in which victims were

cooked upon the hillside lay near this stone, as were also the great hollow log-drums, the "publishers of war" whose rolling beat the cannibal call in old days, and one of which now serves to summon worshippers to church.

An interesting trophy of old days was the anchor of the French brig *Aimable Josephine* which now lies close to the side of the foundation of the temple. This vessel was treacherously cut off at Mbau on the night of July 19, 1834, her captain and most of the crew being murdered. Native wars were waged over the possession of this trophy, the final resting place of which is Mbau.

The corner posts of the house of old Tanoa were still to be seen, and when natives pass these in the night they pluck green leaves and cast them upon the earth, for beneath the ground by the side of each post and embracing it with his arms there stands the skeleton of a victim who was buried alive.

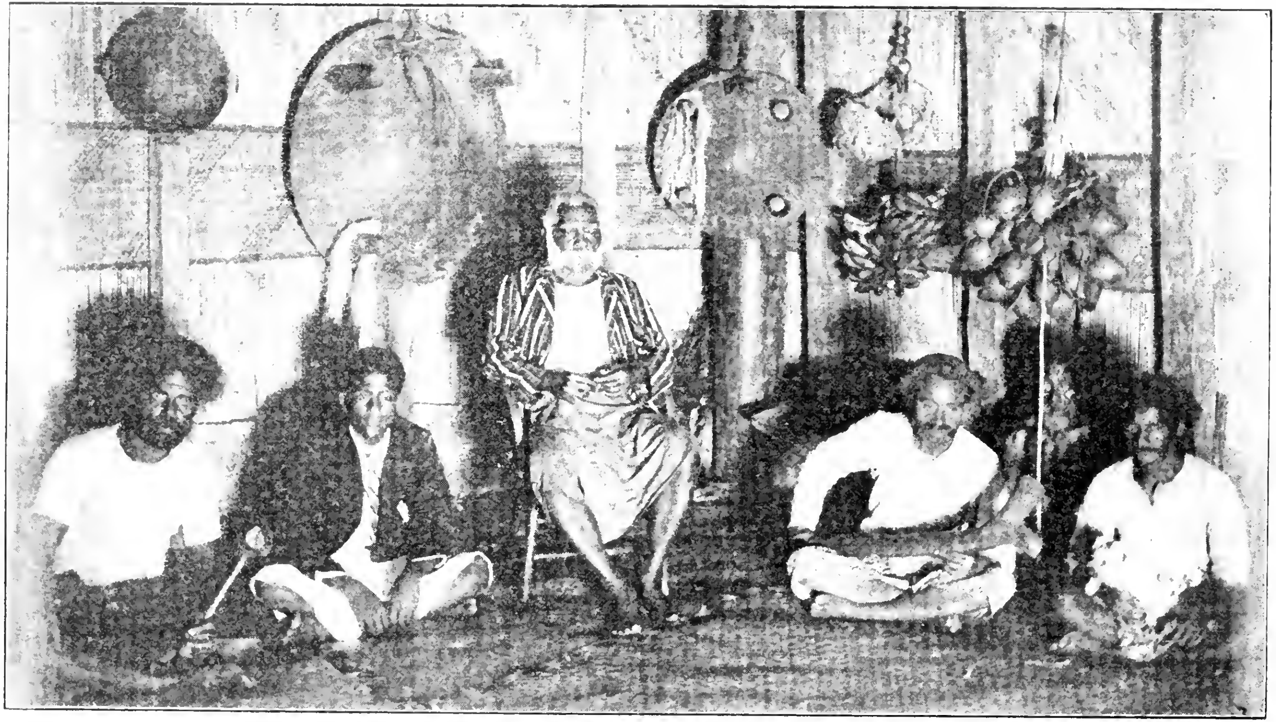
The abutment of the sea wall of Mbau with its made-land, and docks built of large flat stones, is a remarkable example of native engineering, being surpassed only by the canal of the Rewans near Nakelo. Huge canoes, some of them with bows studded with white *Cypræa* shells, lie stranded here and there. The native houses are scattered over the made-land and along the gentle slope at the base of the hill, leaving the summit barren as of old, although here overlooking the city stands the residence of the Methodist missionary, and the graves of Tanoa and of Thakombau, the latter of whom died in 1883.

But exceeding all in interest was Ratu Epele Nailatikau, high chief of Fiji, son and successor of king Thakombau. Unreconciled to the presence of the white man, his memories harked far back to old days and beams covered with woven sennit, and in its treasures of old days, when his family were great and all-powerful in Fiji. Yet, though shorn of power, no king could have been treated with more respect by those around him than was he.

His house in Mbau was a small one, in no way differing from those of the lesser chiefs, excepting in the richness of its Taviuni tapa screens, and beams covered with woven sennit, and in its treasures of old days; the most notable of which was a well-oiled elephant's tusk beautifully browned and polished, which had lain upon the floor since the days of old Tanoa, who once prized it as the largest piece of "coin" in the world. Only the highest chiefs were permitted to enter his house, and even these dropped their titles and crouched silently against the wall awaiting his invitation ere they spoke.

In his every expression and gesture there was a stately consciousness of his high-born ancestry.

Although over sixty years of age, his finely muscular body still stood erect, with its dark bronze skin softened and smoothed through many a cocoanut-oil massage. Upon ceremonial occasions he blackened his



Ratu Epele, Head Chief of Fiji in his House at Mbau in 1899. Three yagona bowls, with their strainers, are hanging upon the wall. Ratu Pope Seniloli is at his right hand, and the others are chiefs of high rank.

face and covered his hair with lime. The little finger of his right hand had been severed at the first joint as an indication of mourning upon the death of his grandfather Tanoa.

He was every inch a king seated in his chair with the noblest of his race crouching silently around him. Whenever he smoked a cigar he condescendingly nodded to some high chief who crawled humbly toward him on hands and knees, delighted at the honor of "finishing the butt."

When he dined, a clean new mat was unrolled upon the floor, and then men and women came crawling in on hands and knees, bearing food for the god-like one, who sat tailor-fashion upon the floor. No commoner ate in the presence of the king, and least of all would the women of his household have presumed to such familiarity. The menu of one dinner at which the author was a guest consisted in an excellent fish chowder served in cocoanut bowls, and yams placed upon four-legged wooden platters, all scrupulously clean and cooked to tempt the palate of the most fastidious epicure. Our plates were banana leaves, and fingers served in lieu of knives and forks. Cups, etc., used by the king are tabu and must not be used by others. The courtiers remained silent while the meal was in progress, only softly clapping hands when the king addressed any of their number. After dinner a bowl of water was placed before the king and the natives again clapped respectfully while he washed his hands.

Even before the advent of the white man, cooking was a high art in Fiji. In fact, these natives had little to learn from us in this direction. Their pottery enabled them to boil or steam their food, and in addition they made use of the oven. This consists in a stone-lined pit within which a wood fire is made. Then, when the stones have become red hot the embers are raked away and the food; pigs, fish, vegetables, etc., are placed within the oven, having previously been wrapped in Tahitian chestnut or bread-fruit leaves, or in the case of man in the leaves of *Solanum anthropophagorum*, a plant allied to the potato. The food is then covered thickly with juicy green leaves which in turn are blanketed with earth. After a few hours all within the oven becomes so thoroughly baked that the ribs of pigs may be torn off and the flesh eaten as in America we do corn upon the cob.

Canoes laden with tribute (lala), for Ratu Epele were constantly arriving at Mbau. These offerings varied with the tribe, for each was charged to bring certain things. Thus one canoe might be laden with great bundles of yams, another with husked cocoanuts tied into bunches, or with yaqona root, turtles, masi, mats, etc. The greatest care was taken in the preparation of the tribute, and, in fact, the natives invariably gave the best they had.

Those who brought tribute carried it humbly to the door of the king's house and crouched close to the wall outside, softly and plead-

ingly clapping with their hands. Hearing the plaintive sound two chiefs of the king's household, who had hitherto been sitting motionless as statues within the room, moved to one and the other side of the door. The head of a pig, a large bunch of cocoanuts, or a turtle would then be timidly thrust part way within the opening, and a tremulous voice outside would beg that his majesty, their great and gracious lord, would condescend to accept as tribute so mean and unworthy an offering as their poverty forced them to present, trusting that in his greatness he would continue to protect and show them favor. When the voice ceased, the two chiefs at the door would critically inspect the proffered specimen of tribute, calling attention to its faults as well as to its qualities, and if its acceptance was recommended, all the chiefs who had been crouching sphinx-like against the wall within the house would show signs of life and majestically clapping their hands murmur "A! woi! woi! woi!! A tabua levu!" (a wonderfully large whale's tooth!). Upon which the king himself usually spoke a few words and the tribute was formally accepted. So abundant was this tribute that great heaps of taro, yams, cocoanuts or turtles were nearly always to be seen upon the village green of Mbau.

In the old days, wars were waged over the slightest inattention to this matter of tribute. The island of Maliki was charged to provide turtles for Tanoa, but one day they presumed themselves to eat one of the turtles they had caught; hearing of which Tanoa sent a fleet of war canoes, and every man and woman on Maliki was killed, the children being captured in order that the boys of Mbau might club them to death and thus earn their titles of Koroi (killers of men).

The old king spoke not a word of English, but he was fond of reminiscence. He remembered the *Peacock* of the Wilkes expedition, being then a boy of about 8 years. He also spoke admiringly of Professor Moseley, of the *Challenger*, and seemed saddened when told that he was dead.

The freedom with which he volunteered to discourse upon events of cannibal times was surprising. He said that one day when he was a little boy he had entered the house of Tanoa during the dinner hour, and his grandfather, who always loved him, had given him the tongue of the Mbakola[6] (man-to-be-eaten) and its taste was vinaka (good). After this he "often dined with his grandfather," who "had a new man nearly every day." Wilkes states that the Fijians esteemed women more highly than men, but Ratu Epele declared that the best of meat were old, lean men "whose flesh was red and whose fat was yellow," and whose taste was "like pork with bananas." Women, he declared,

[6] Long pig, "Vuaka-mbalavu," applied to designate cooked man, is not grammatical Fijian, but is derived from a joke of the inveterate old cannibal Tanoa.

were "covered with a layer of fat" and white men he had been told were salty or flavored strongly with tobacco. In old days in Fiji, the highest praise one could bestow upon a dish was to liken it to a cooked man. When in Fiji, I several times overheard the remark "were it not for the English I would eat you," and in quarrelling the commonest slur is to call an antagonist (Mbakola) a man to be eaten. Our abhorrence of cannibalism, which is after all a sentimental matter in so far as the mere eating is concerned, was not shared by the old Fijians of experience, for "men are good; indeed the best of all meat," and as Ratu Epele once said "he never met a man without thinking how he would taste."

Some Fijian names for food are curious; thus bula-na-kau signifies beef, for when Captain Eagleston brought the two original cattle to Fiji he told the natives that the animals were a "bull and a cow."

Ratu Epele delighted to play at draughts with a tawny-haired albino chief whose light skin was profusely bespeckled with brown blotches and whose eyes were dull blue. This chief's function seemed to be solely that of a messenger and draught player, and invariably the games were won by the king, for no matter how great an advantage the albino might win, he "committed suicide" at the last by placing all his pieces at the mercy of his lord and master.

Ratu Epele, the most interesting chief in the Pacific, died in 1901, and with him there passed away the last champion of the old in Fiji. Born of the highest rank and to a life of war and action, fate had robbed him of his birthright and left him but dreams and memories. Like the lingering spark of a fire that can never burn again, this spirit of old cannibal days faded into oblivion. His son, the Honorable Ratu Kadavu Levu, who succeeded him as Roko Tui Tailevu, has been carefully educated under British auspices, and is a member of the Legislative council.

The cleanliness of Fijian houses is remarkable, indeed in heathen times they were far more careful in this respect than at present, for the least offal of any description, even a hair, might be used by an enemy to bewitch its originator. Even to-day the fear of witchcraft, Ndrau-ni-kau, is very real in Fiji. In order to bring ill-fortune to your enemy, you have but to discover something which he has cast off and burn it wrapped in the proper leaves, reciting certain spells. Or you may bury a cocoanut beneath his hearth, or slowly melt the wax from his image thus causing your victims lingering decline and death. The missionaries have made every effort to destroy this belief, but unfortunately they do not seek to replace it by a more wholesome understanding of the nature of filth-diseases, and thus as faith in witchcraft declines certain bodily ills increase.

In common with other south-sea islanders, the Fijians were a cere-

monious people and every important affair of life was ordered in accordance with a rigid etiquette which unhappily in many instances is falling into neglect before the levelling influence of the white man's law.

Thus in the old days, the yaqona (kava of Samoa) was drunk by chiefs alone, and then only upon ceremonial occasions, but now all may partake of it and the excess thus engendered is one of the minor causes of the decline of the population. Wilkes, and also Williams, in his work on Fiji and the Fijians, describes the ceremony at Somo somo where it was most elaborate. Early in the morning the herald stood in front of the chief's house and shouted yaqona ei ava, and all within hearing responded in a shriek Mama (prepare it). Then the chiefs and priests gathered within the king's house, while all others remained at home until the king had drunk his yaqona. Pieces of the root of the *Macropiper methysticum* were distributed among the young men, who must previously have rinsed their mouths and whose teeth must be perfect. The chewed root having been deposited in the form of relatively dry pellets in the bottom of the bowl, the herald announces to the king "Sir with respect the yaqona is collected." The king replies "Loba" (wring it). The bowl is then placed before the chief, who skilfully encloses the chewed fragments of root within fibers of hibiscus or cocoanut husks and finally wrings the fluid through this sieve, thus removing from the bowl all pieces of chewed root, and leaving within it a milky-yellow brew. While the straining is progressing, the priest chants a prayer in which the company finally joins. The first cocoanut cup is always handed to the king, who pours out a few drops as a libation to the gods and then drinks while the assembled company sing, Ma-nai-di-na. La-ba-si-ye: a ta-mai ye: ai-na-ce-a-toka: Wo-ya! yi! yi! yi!, finishing with a clapping of hands and a wild shout which is passed from house to house to the uttermost limits of the village. After the king, the company is served in the order of rank until all have partaken. In old times, it is said that yaqona was grated in Fiji, but that the Tongans introduced the method of chewing. Having tried it, I must confess that the chewed root is less unpleasant in flavor than the grated, but at best it resembles a combination of quinine and camphor and is certainly an acquired taste. When drunk to excess, it temporarily paralyzes the arms and legs, at the same time exciting the brain. Thus violent quarrels are apt to occur at yaqona bouts, but the combatants are unable to injure each other. When the chief falls into a stupor the wives of the other participants carry their protesting husbands home. A dull headache upon awaking is the penalty for this over-indulgence, but the evil effects are slight in comparison with those resulting from alcoholic excesses.

The British government has, however, prevented alcoholism among the natives; for each Fijian who desires to imbibe must annually ob-

tain a license which he is obliged to exhibit whenever he purchases a drink at any public bar, and if arrested for drunkenness his license is confiscated, not to be renewed, and moreover the bartender is heavily fined if he be detected in selling drinks to natives who possess no license.

The Fijians of to-day are more orderly and sober than, and quite as contented as are any peoples of European ancestry, and illiteracy is rarer in Fiji than in Massachusetts. You were safer even fifteen years ago in any part of Fiji, although your host knew how you tasted, than you could be in the streets of any civilized city. It is clear that in *disposition* the Fijians are not unlike ourselves, and only in their time-honored *customs* were they barbarous. Indeed the lowest human beings are not in the far-off wilds of Africa, Australia or New Guinea, but among the degenerates of our own great cities. Nor are there any characteristics of the savage, be he ever so low, which are not retained in an appreciable degree by the most cultured among us.

Yet in one important respect the savage of to-day appears to differ from civilized man. Civilized races are progressive and their systems of thought and life are changing, but the savage prefers to remain fixed in the culture of a long past age, which, conserved by the inertia of custom and sanctified by religion, holds him helpless in its inexorable grasp. Imagination rules the world, and the world to the savage is dominated by a nightmare of tradition.

It is not that there are no individuals of progressive tendencies among primitive tribes, but the careers of their Luthers and Galileos are apt to be short and to end in tragedy. Indeed, only three hundred years ago our own leaders of progress struggled at the risk of their lives against the prejudices of their contemporaries. Even with us every effort of progress engenders a counteracting force in the community which tends to check its growth and to preserve the present status, accepting the acknowledged evil of to-day to preserve the even tenor of our way, for fear of the new is akin to the superstitious dread of the unknown. Whether the race be savage or civilized depends chiefly upon the nature of the customs that are handed down as patterns upon which to mold life and thought. The more ancient the triumph of the conservatives the more primitive the culture which is conserved, and the more likely is it to be crude and barbarous. A wonderful instance of fixity of custom is afforded by the race which in the ice-age lived in the caverns in the valleys of the Dordogne and the Vezere in central France. Their skull measurements indicate that certain of these cave-dwellers were Esquimo and their implements and works of art are the same as those of the Esquimo of the Arctic regions of to-day, who have thus remained unchanged throughout unknown thousands of years, unaffected by their great journey northward following the edge of the retreating ice.

Among all races religion is the most potent power to maintain tradition, and for the savage religion enters into every act and thought. To him as to the ancient Greeks everything is a personification of some spirit—everything is somebody. The waterfall is such, for can you not hear the laughter of the nymph, the clouds are spirits for they come and go as only gods may do, and every beast and bird and plant and stone is but the embodiment of a ghost or tribal hero.

Yet it is probable that no savage has ever been more under the dominion of a world of omens and portents than was Louis XI, and even to-day the breaking of a mirror, or the number thirteen, or a stumble while crossing a threshold, remains of significance to many of us. All matters of sentiment and credulity are closely wrapped up in this entanglement of superstition; it is hard to divorce ourselves from the idea that moving machines have life and disposition. We must perforce associate sublimity and grandeur with the inert rock-mass of the Alps, and the great trees under which we played as children are sentient beings to our imagination, and our hearts ache as for the loss of life-long friends when we find them fallen to the woodman's axe. A cold heartless world it indeed would be were we not illogical and therefore "savage" in our sentiments and loves.

Upon analysis we find that lack of sympathy for the savage and ignorance of his tradition blinds our judgment and causes us to regard as ridiculous in him things which we consider to be quite natural in ourselves. The cleverness of the Yankee who sold wooden nutmegs is quite amusing, but the Japanese who counterfeits an American trademark is criminal.

There is within us Europeans an inbred contempt for all that is alien, and this trait, being the dominant characteristic of Christian peoples, has enabled us through aggressive intolerance to impress our customs upon all other races without ourselves being influenced by the cultures we have overawed into a semblance of our own.

In strange and possibly ominous contrast with ourselves, the Japanese have for ages been keen to discover the good things of alien cultures and quick to accept them as their own, while we must remain all but unmoved by the example of their ennobling patriotism and mastery of self, the happy simplicity of their family life, their respect for worthy ancestors, their modesty, and their inbred grace of deportment; and as for their exquisite art we chiefly relegate it to our museums, and their fine chivalric code, the bushido, remains all but untranslated into our language, much less has it entered into our thought.

The savage may know nothing of our classics, and little of that which we call science, yet go with him into the deep woods and his knowledge of the uses of every plant and tree and rock around him and his acquaintance with the habits of the animals are a subject for constant won-

der to his civilized companion. In other words, his knowledge differs from ours in kind rather than in breadth or depth. His children are carefully and laboriously trained in the arts of war and the chase, and above all in the complex ceremonial of the manners of the tribe, and few among us can excel in memory the priests of old Samoa, who could sing of the ancestors of Malietoa, missing never a name among the hundreds back to the far-off God Savea whence this kingly race came down.

One may display as much intelligence in tracking a kangaroo through the Australian bush as in solving a problem in algebra, and among ourselves it is often a matter of surprise to discover that men laboring in our factories are often as gifted as are the leaders of abstract thought within our universities. In fact the more we *know* of any class or race of men the deeper our sympathy, the less our antagonism, and the higher our respect for their endeavors. When we say we "can not understand" the Japanese we signify that we have not taken the trouble to study their tradition.

It is a common belief that the savage is more cruel than we, and indeed we commonly think of him as enraged and of ourselves in passive mood. Child-like he surely is, and his cruelties when incensed are as inexcusable as the destruction of Louvain or the firing of Sepoys from the guns, but are they more shocking than the lynching or burning of negroes at the stake, events so common in America that even the sensational newspapers regard them as subjects of minor interest.

Clearly, despite our mighty institutions of freedom, efficient systems of public education and the devotion of thousands of our leaders to ideals of highest culture, there remain savages among us. Mere centuries of civilization combat the æons of the brute. Within each and every one of us, suppressed perhaps but always seeking to stalk forth, there lurk the dark lusts of the animal, the haunting spirit of our gorilla ancestry. The foundations of our whole temple of culture are sunken deep in the mire of barbarism. It is this fundamental fact which deceives us into the impression that a few decades of contact with men of our own race will suffice to civilize the savage. True they soon learn to simulate the manners and customs of their masters, but the imitation is a hollow counterfeit, no more indicative of enlightenment than is the good behavior of caged convicts a guaranty of high mindedness. To achieve civilization a race must conquer *itself,* each individual must master the savage within him. Cultured man has never yet civilized a primitive race. Under our domination the savage dies, or becomes a parasite or peon.

TRADE UNIONISM VERSUS WELFARE WORK FOR WOMEN

By ANNIE MARION MACLEAN, Ph.D

CHICAGO

PERHAPS the most popular phase of philanthropic endeavor at the present time is that which deals with the improvement of industrial conditions for women. That their lot is unduly hard is evidenced by the facts of the case. Women have always worked and are therefore no innovation in industrial life; yet the spectacle of their toiling in ever-increasing thousands in this country has stirred alike alarmists and reformers, and they have given publicity to hardships always endured by the workers, but hitherto undreamed of by the more favored members of society. Eight millions of women are now engaged in gainful occupations and the great majority of them are under twenty-four years of age.

The youthfulness of so large a number of women makes its own appeal for sympathy, even though it is not powerful to bring about more equitable arrangements in industry. Society, it would seem, is usually lavish with sympathy, but niggardly with justice. But of late we have become obsessed with the idea of meting out justice to the unborn. The inevitable outcome of this, of course, must be fair treatment to the potential mothers. In so far as it results in sane activity in their behalf well and good. Four millions of the eight classed as women in gainful occupations are industrial wage earners, a group sufficiently large to leave its impress on the health and morals of the future.

It can not be denied that modern methods of industry tend to push oppressively hard upon unskilled young women, who have neither ability nor training to enable them to engage in interesting tasks. They are often forced into the most monotonous kinds of labor, where they are poorly paid and obliged to work at nerve-destroying speed. A dawning interest in public health has focused attention upon the physical effects of such toil, and it has also, coupled with certain moral conditions, led to the important investigations into industrial conditions for women that have been carried on during the past few years. People who, a decade or two ago, neither knew nor cared how or where their clothes or food were made, or by whom, now exhibit a lively interest in these matters. It is an awakening of social conscience that omens well for the worker. But even an awakened community works slowly in the matter of reforms. It takes a long time to enact and enforce desirable legislation. In the interim something must be done. Much in fact has

been done by organizations large and small, but out of all this endeavor two types of undertakings stand out conspicuously as coming close to the heart of labor and trying to correct abuses. They are trade unionism and employer's welfare work. A consideration of these two agencies, in so far as they affect wage-earning women, forms the subject-matter of this discussion. The two agencies represent distinct, even antagonistic methods, and in fact are usually mutually exclusive.

For about half a century, the trade organizations have been striving, by fair means and foul, to get a voice in the conduct of the businesses in which they work, for the purpose of improving their own condition. The end for which they have striven is laudable. They have been calling for sanitary workshops and living wages; for shorter hours and more certainty of employment; and all the time emphasizing their right to be heard. This movement is especially deserving of notice because it is a movement by the wage workers, for the wage workers—those who are admitted to need help striving to help themselves. This, in theory at least, is the most hopeful of all undertakings, and it is the spirit that should be fostered. The working people have set up for themselves a definite standard of living, which they desire to reach, when they organize together in their trades.

Whatever may be said about methods sometimes employed by the trade organizations, it must be admitted that their theory of industrial betterment is rational. They stand for the uplift of labor, and theirs is a herculean task. They are attempting to push themselves up against forces apparently conspiring to keep them down. This opposition has lent a strength and militant vigor to their purpose. They hold up to themselves the definite ideal of self-improvement, and the tenacity with which they cling to this ideal shows the faith they have in it. A more comfortable working class is their hope. They pursue their purpose oftentimes with set teeth and clenched fists, and their zeal is an inspiration in itself. They have a goal, and with steadfast purpose they are striving to reach it.

Industrial betterment of this kind tends to produce a virile body of citizens, and the test of any ameliorative work must, in the last analysis, be the effectiveness of the citizens it develops. This method of improving conditions is only beginning to seize the imagination of women; its possibilities are only beginning to be realized, and by representative bodies of women fully as much as by wage earners themselves. The great majority have been slow to avail themselves of the benefits arising from organization. Many of the workers feel that their stay in the industrial world is temporary, and they are either indifferent to the conditions under which they must work for a time, or they are unwilling to subject themselves to what they frequently regard as the tyranny of leaders, preferring rather to endure low wages and bad

sanitation if need be till marriage sets them free. This and other reasons which have kept women wage earners from adopting union ideals in the past are still operative it is true, but the more intelligent are beginning to see the benefits of organization, and are uniting with others of their trade for mutual betterment. Union men have not always been friendly toward unions for women, chiefly for the reason that they feared the acceptance of women into their ranks might militate against increased wage scales. Their attitude has changed, however, and this has had its share in stimulating an interest in organization among even young women workers.

Many persons interested in social betterment are now growing sanguine over the possible future of women's unions, owing to certain successes achieved by them in the garment and other trades in recent years. Hitherto the union has flourished most in time of stress. There is inspiration in a fight, and, moreover, a fight is sometimes necessary to overcome injustice. But these working women need, too, the ministry of peace, and when the unions shall have passed through their militant stage, the women workers will doubtless be the gainers. Union women are now standing shoulder to shoulder in their effort to obtain higher wages, shorter hours and healthful conditions of work. If they have these, they say they can provide themselves with opportunities for education, and recreation, and other desirable things in life. They are fighting for a chance to work, and a chance to live.

The other form of industrial betterment under discussion is that carried on by more or less philanthropic employers, and through the National Civic Federation called "welfare work." Such work is as varied as the employer's appreciation of needs, or ingenuity in suggesting remedies for existing difficulties. With one it may take the form of shower baths, and a system of profit-sharing; with another hot noonday lunches and dancing classes; while still another may discharge what he considers his duty by providing club rooms for men, and aprons for women. But whatever the method pursued, vastly better physical conditions have resulted. Welfare work has given us model factories, and beautiful surroundings must ever be an incentive to right living.

Several hundred employers in the United States are carrying on some form of betterment work for their employees, while ten or a dozen stand out prominently for their unusual, even notable, undertakings. In general, welfare work may be said to include: (1) improved physical conditions; (2) opportunity for rest and recreation; (3) educational work; (4) benefit funds.

Now each of these things is good in itself, and employees, while as a rule willing to recognize the truth of this, yet are more or less suspicious of their employers' undertakings. They do not object to the

good things, but to the methods of bestowing these good things. Many thoughtful employers, having been beset by labor difficulties, have concluded to make conditions of work pleasanter, in the hope of banishing dissatisfaction. The plan has been successful in some cases. Sometimes these employers are poor psychologists, inasmuch as they fail to understand why blissful content does not follow on the heels of some gift. The young women asked, perhaps, for higher wages, and were given rest rooms and free lunches. Why, forsooth, should they not be happy? Chiefly for the reason that a sop never satisfied anybody. However, many who have grown to distrust union methods are looking with hopeful eyes to employers' betterment schemes as the final solution of labor difficulties. Capital and labor working together for mutual benefit is undoubtedly the ideal condition. But they must really work *together* if the most desirable results are to be obtained.

Having before us the main features of trade unionism and welfare work, let us now discuss these two agencies. As was stated before, the final test of the value of an institution is the type of citizen it produces. When we seek to improve an individual, we have in view not only the present comfort of that individual, but his future usefulness to society. We feed a hungry boy, not only to keep him quiet and make him fat, but to make him a man. So in all ameliorative work we must keep ever before us the final purpose of it all. The work in itself is of value only in so far as it helps to make better men and women of those whom we would help.

Our duty is toward society at large, and we can discharge it only by helping to promote good citizenship. Now in order to be the best type of individual one must have ever before him an ideal, and an instiution which would elevate any class in society must present to that class a definite ideal; it must give it something for which it must strive, for I am bound to believe that no individual or group will advance very far without this inspiration. "Without a vision all the people perish." Now if we accept this doctrine of social righteousness based on ideals, let us see how far these two industrial betterment agencies under consideration are in harmony with it.

The trade unions in all their bickerings, and turmoil, and failures, and successes, have never lost sight of their goal of better working and living conditions. The union holds up to its members the ideal of class betterment. They are stimulated to further endeavor by this. We must therefore concede to the trade unions a place in our scheme of industrial regeneration. The principle for which the union stands is sound.

Let us now enquire into the social value of employer's undertakings. Here we come to an entirely different situation. The employer is the active force, the employee the passive agent at the outset, and if this condition changes it is owing to the tact of the employer. Welfare work,

then, comes to be a bestowing by him who has upon those who have not.

The wealthy employer is touched perhaps by the weary face of one of his women workers, and he immediately opens a rest room; he sees her drinking cold coffee from a can, and he makes plans for serving a hot lunch; he sees her look longingly at a few flowers beyond her reach, and he transforms his factory into a veritable garden; he sees her standing at her work with weary limbs, and he straightway orders high-backed stools. Any employer who allowed his heart to accompany him on a trip through his factory or store would see a score of things he could do for the comfort and happiness of his employees, and if he went forth and did them would be himself a better citizen thereafter. But what of the people whom he has helped? What ideal has he given them? They are recipients of favors. They may have better health on account of his gifts; they may even be happier. But there is something in the average American working man or woman that resents even health and happiness if mixed with patronage; and unless an employer has phenomenal tact his efforts are likely to be regarded as paternalistic. Working women as a rule accept favors more readily than men, with the result that they are more prone to betray some of the characteristics of spoiled children. On the employer's side there is always the temptation to turn to business profit the improved conditions his generosity has made possible. His welfare work may thus become simply advertising, and his employees may be exploited to their humiliation. The employer undoubtedly is entitled to whatever commendation a humanitarian policy may merit, but when that policy is adopted solely for the financial benefits that may accrue from popular approval, it becomes questionable, possibly meretricious, from the ethical standpoint, and certainly should not be accorded a place in the field of ameliorative undertakings. Such work belongs simply to the realm of advertising, and has nothing whatever to do with the broad ethical movement we are considering. Its contribution to the solution of industrial difficulties is a negligible quantity.

The employer who installs shower baths, and then with a blare of trumpets—possibly accompanied by moving pictures of employees performing their free ablutions—calls his goodness to the attention of the passer-by, belongs to the same class as a circus manager who exploits the tricks of his animals, not because he poses as the savior of the animal creation, but because he hopes it will induce money to flow into his coffers. We must, then, make a clear line of demarcation between the schemes of an enterprising publicity agent and genuine purposeful betterment work. The value of welfare work must ever depend on the employer who undertakes it. So far as employees are concerned, they are actuated by no strong purpose. They have greater comforts without the spiritual stimulus of working to get them. Such undertakings do not present a definite ideal to strengthen and enrich character, to

develop the best type of citizenship. The chief weaknesses, then, of this system seem to me to be an inherent tendency toward paternalism, with its consequent emasculating or embittering of labor; its lack of the cooperative spirit; and its failure to hold up an ideal.

There are many things in life of more importance than window boxes filled with trailing vines and bright blossoms; there are more pressing needs for girls than fresh white aprons. And the would-be philanthropic employer who does not recognize this is doing less than his whole duty. While providing for the physical comfort of their employees, employers should recognize the fact that they assume certain moral as well as economic responsibilities when they bring together large numbers of workers. And it is this ethical side of welfare work that is most significant; it is the side that has the most direct bearing on good citizenship. It is quite possible for a working woman to discharge her full duty to society without having luxurious couches on which to lie when she grows ill or weary from toil, but it is not possible for that woman to fulfill her duty as a member of the social group unless she is capable of exercising the power of choice, of standing firm as a moral entity, of grasping and holding to a definite ideal of progress.

Now my contention is that the present tendency of welfare work is not to strengthen labor's power of initiative, and is not to summon to the fore that virile zeal which belongs to sturdy manhood and womanhood. When the employer has been the means of rousing his employees to action, of encouraging them to evolve methods of betterment, and of stimulating them to an appreciation of their opportunity to do things for themselves, the situation is much more hopeful. Some few employers in this country have been able to do this, but the general trend of the work is in another direction. And employees, surfeited with comfort for which they can give no return, are liable to become limp of will and uncertain of purpose. Their power of initiative becomes dwarfed. They are always open to the charge of ingratitude. The pampered children of industrial Utopias may become unfit for the competitive system of industry. There are remedies of course that could be suggested for all these difficulties, but it is not my purpose here to show how to revolutionize welfare work, but rather to point out its present tendency.

Now having before us the essence of the two betterment movements for women known as trade unionism and welfare work, and some comments thereon, it becomes pertinent to enquire which one merits the greater degree of approval and support from people interested in industrial and social amelioration, so far as young wage-earning women are concerned. The question really resolves itself into a very simple one, but nevertheless one that we may not be able to answer satisfactorily for a generation or more, that is, which method tends to give us the more efficient women, women who can function most capably in a democracy?

EURASIAN WATERWAYS IN TURKEY

By LEON DOMINIAN
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THE circumstance of contiguity by which the southeastern end of the Balkan peninsula almost abuts against the extreme northwestern shore of Asia Minor provides an Eurasian ford which has facilitated human intercourse between Europe and Asia. The Dardanelles, the Sea of Marmora and the Bosporus constitute in reality a single strait. From Tertiary times to our day a normal and interdependent sequence of events has occurred on its site. In the prehuman period it is possible to trace land-fracturing followed by gorge-carving, valley submergence and strait formation. The post-human development witnesses conversion of the locality into an important section of one of the most widely traveled highways of mankind. Two main routes intersect each other in the dividing waters. Their courses leading from northwest to southeast and from northeast to southwest are at right angles to each other. In considering the value of the region as part of a much trodden route, it is necessary to ascribe proper importance to its lines of communication with Europe and Asia.

A Balkan zone of depression extending west and south of the Balkan uplift affords natural access between the valley of the Danube proceeding from the heart of Europe and the Dardanelles-Bosporus passage. It is constituted by the wide valley of the Morava and the narrower Nichava course leading to the Sofia basin, whence penetration into the Thracian plains is obtained by the Maritza valley.

The corresponding function for the Asiatic shore is performed by the valley of the Sakaria and to a lesser degree by the Pursak river depression—both trending westward from the high plateau of western Asia.

The main roads from the Bosporus or the Dardanelles to the Sakaria river valley skirt the shores of the straits and the Marmora as they follow a coastal lowland fringing the Dardanian and Bithynian heights. At Panderma, however, the old highway strikes inland slightly south of east to Brusa in order to avoid the elevated plateau intervening between the Marmora and Lake Abullonia. Thence, still following a line of least elevation, it wends its way towards the small harbor of Ghemlik (the Cius of Græco-Roman times) until beyond Isnik (ancient Nicæa of ecclesiastical fame) it debouches into the waters of the Sakaria.

The geological evidence at the shores of the Dardanelles and the Bosporus reveals the probable continuity of land at both points in a

time not far remote. A narrow band of the Miocene beds of the Gallipoli peninsula extends along the eastern coast of the Dardanelles. The lower Devonian strata and igneous flows of the European side of the Bosporus reappear on its Asiatic shores. In both straits the land-splitting fracture which gave rise to watery channels is an event of late geological times. Originally gorges of rivers flowing from northeast to southwest, the straits assumed their present geographical form as a result of depression. As one stands on the Sheitler hill midway between the Black Sea and Marmora entrances of the Bosporus the correspondence of promontory to bay and bay to promontory is discernible in the entire range of vision swept by the eye to right or left. A similar relation between opposite shores recurs in the Dardanelles with the only difference of size of landforms for, in the longer strait, the headlands are bolder while the bays attain deeper and wider proportions.

The importance of the region as a fording place can be gathered from the distribution of the larger cities within its boundaries. Setus, Abydos and Madytus on the Hellespont grew on the site of the nearest convergence of the European and Asiatic land-masses. The same is true of Byzantium, with the added circumstance that the promontory on which it was founded afforded an admirable strategic site. Ilium, at the southwestern entrance of the waterways, also owed its importance during antiquity to commanding position. Its disappearance as a center of urban life was the result of geographical disadvantages. The ancient city lacked a convenient harbor, above all. Land communication with Asia Minor was arduous on account of the mountainous character of the country extending beyond the city walls. Byzantium, however, at the opposite extremity of the straits had been provided by nature with the very facilities for intercourse which had been denied Troy. The economic conditions which were responsible for the passing of the latter city determined the survival and increasing importance of the Byzantine capital.

The narrowness of the Eurasian waterways permitted continuity of travel over this intercontinental route while the very existence of the straits allowed uninterrupted maritime travel from Black Sea harbors to the farthest known seaports of the western world. Modern railway communications have been benefited by the former circumstance. The sea commerce of medieval days thrived on the latter. In fact, the configuration and location of the region has always affected humanity.

Assumption of the wandering of Alpine brachycephals from the Hindu Kush to as far west as Brittany appears to be substantiated by the distribution of the type. The connecting link between members of the race in western Europe and their Asiatic prototypes is found in the Armenoid group of Asia Minor.[1] Probably the earliest fording of

[1] Ripley, "The Races of Europe," New York, Appletons, 1899, p. 448.

Eurasian waterways was undertaken by this race in the course of its westerly spread.[2]

This specific case of migration may be considered as part of the powerful "trans-humanizing" process moving in an east-west direction which has taken place on the Eurasian continent. Interdependence between this movement and the conformable trend of the main lines of Eurasian structure as well as correlated climatic zones still remains to be determined. Ultimately the entire problem may be found to be connected to mechanical effects of our planet's rotation.

Since the dawn of historical times the Propontine area and its outlets have borne the vessels of adventurous traders and colonists. Early extension of Hellenic influence to the easternmost shore of the Black Sea was rendered possible by the advantages offered by this water route to Greek pioneers. The foundation of Byzantium in 657 B.C. promoted the intercourse between the east and west which at that time was largely restricted to relations between the Ægean and Black Seas. A half-way station was established on the unique site of the modern capital of the Sultans. Here a system of powerful defenses reinforced by the encircling waters of the Golder Horn, Bosporus and Marmora provided long lease of existence to the city which both Europeans and Asiatics regarded as the gateway to rival continents.

Between the Ægean mouth of the Hellespont and the Euxine outlet of the Bosporus, Asiatic invaders of the western world and European colonizers of the east have always found the shortest watery stretch of their respective routes. This was an important point at a time when control of natural forces was in a still undeveloped stage. The danger of impairing the cohesive strength of an army of invaders was also minimized.

These considerations probably led Darius to adopt the Bosporus route in the expedition sent against the Scythians in 513 B.C. His cohorts tramped from Asia into Europe over a bridge of boats thrown across the Bosporus in that year.[3] From that time on various incursions of Asiatics into the western continent were to cross the water of these straits.

During the second Persian war the bridging of the Hellespont by Xerxes' generals is commonly reported as having been undertaken between Abydos and Madytus. Both of these sites lie north of the narrowest section of the Dardanelles,—the Kilidbahr-Chanak gap, barely a mile in width. They correspond approximately to Nagara Point and the paltry hamlet of Maitos, between which the distance of the straits attains three miles. The current at the wider section is not as swift.

[2] *Cf.* map of Asiatic Migrations in The Wanderings of Peoples, by A. C. Haddon, Cambridge, 1912.

[3] Herod., B. IV., 86–89.

There the double row of pontoons built by Xerxes's engineers in 480 B.C. could be moored with less danger of their drifting with the southerly flowing waters. It is not improbable that the bridge thrown across the Hellespont on this occasion was started near the conveniently situated mouth of the Rhodius River and extended to a point about two and a half miles south of Madytus.

Half a century later the Hellespont was crossed by a counter human current which was destined to flow to the shores of the Indian Ocean. Macedonian supremacy over Greek states at that time depended largely on the conquest of Asia where ready help against the kingdom bequeathed by Philip to Alexander was always to be found by the states of Thessaly and the Peloponnesus. The bulk of the Macedonian phalanxes were transported from Europe to Asia between Sestus and Abydos in 334 B.C. It is likely that minor contingents crossed between Elacontus and the Acheau's cove with Alexander who was proceeding to Ilium.

The main fording points selected on this occasion lie north of the previous passage. The distance between Sestus and Abydos is also approximately one mile. The advantage of the site, however, is due to the moderation of the current which flows between these points with about half the swiftness characterizing its onward rush through the contracted outlet on the south.

When the convergence of all roads to Rome had become well established in the first century after Christ, the Bosporus was the shortest watery section of a long highway which began at the Appian way and extending through Ancyra, Tarsus and Antioch, attained Egypt and Mesopotamia by way of branches diverging at the last-named city.

The easterly spread of the Roman Empire, however, caused the Bosporus to replace the Roman Tiber as the hub of spoke-like roads leading to the remotest confines of the Cæsars' vast administrative domain. The evidence afforded by the Peutinger Table and the Antonine Itinerary on this translation of center is conclusive. In the words of Ramsay[4] the map

> was made in the Byzantine period by a person who was accustomed to the Byzantine system of roads radiating from Constantinople across Asia Minor, and who tried to represent the roads on this idea. . . . But no road which leads across country from the Ægean coast is represented with any approach to completeness: the roads in this direction are given in fragments with frequent gaps.
>
> The same remark applies to the Antonine Itinerary: the compiler is interested chiefly in the roads to Constantinople. . . .'

In the early centuries of the Christian era the advantageous location of the waterways favored the development of trade intercourse between Europe and Asia. From the European coast roads led to the great

[4] "The Historical Geography of Asia Minor," p. 48.

commercial cities of lower Austria which at that time, and especially from the sixth to the twelfth century, were the depots and distributing centers of Oriental merchandise. Thither traders from the northernmost and westernmost sections of Europe came to supply themselves with the spices and rareties of the Orient. The Avars, who had settled in the valley of the Danube and who traveled back and forth in the wide valley of their choice, were the principal commissioners between Constantinople and the storing centers of Lower Austria.

At the apogee of Byzantine might the region occupied an eminently central location in the civilized world. In the sixth and seventh centuries from north to south and between east and west the Byzantine Empire was in every sense the country of the core. A large proportion of world commerce carried on between cardinal points of the compass passed through Eurasian waterways. This trade route grew in importance during succeeding centuries. It flourished especially throughout the period in which Italian cities acquired commercial supremacy.

Between the eighth and ninth centuries the commerce of Europe centered at Constantinople "more completely than it has ever since done in any one city." A commercial aristocracy was created in Byzantium as a result of this remarkable trade activity. The body of wealthy merchants rapidly acquired political power, and it became necessary for usurpers to obtain their support. Finlay, basing himself on Theophanes, records the case of Empress Irene, who was obliged to lower the toll levied at the straits of the Hellespont and the Bosporus in order to find favor with the business men of the capital at the time she was preventing her son from reigning.

In the course of the eight crusades between 1096 and 1270 the straits of the Bosporus provided easy passage from Europe into Asia to the soldiers of the cross marching against the infidel. Throughout the two centuries of faith-inspired fighting the nations of the world met in Constantinople. From the very start of the religious movement the bands of crusaders followed the roads provided by nature to this city, there to unite forces before proceeding through Asia Minor to Palestine. The four leaders of the first crusade set the precedent by convening in the Byzantine city. From Ratisbon along the valleys of the Danube, the Morava and Maritza, Godfrey of Bouillon led his host to the shores of the Bosporous. Adhemar of Puy and Raymond of Toulouse, proceeding from Burgundy through northern Italy, western Croatia and Bosnia, also attained the classic strait after crossing Albania, Macedonia and southern Thrace. The army of Bohemond and Tancred left Brindisi and landed in the bay of Valona, whence it was directed across the Balkan peninsula to the Byzantine capital. Robert of Flanders and Hugh of Vernandois marched through central Italy and, taking ship at Bari, crossed to Durazzo, there to begin the overland journey, the first

stage of which ended at Constantinople. Beyond the imperial city, in Asia Minor, the four routes which had marked the progress of the first crusade in Europe merged into a single trail over which the motley crowd of friar, beggar and adventurer, gathered from every European nation, steered its way towards Jerusalem.

From A.D. 1250 to 1425 Black Sea coast towns constituted western termini of important caravan routes proceeding from the heart of Asia. Tabriz, the great rendezvous of traders traveling from China, India or Arabia, was connected to Trebizond by the valley of the Arax. The seaports of Samsun, Poti and Tana also received the products of Asia destined for western Europe. The bulk of this Black Sea commerce was in the hands of Venetians and Genoese. Natives of the independent cities of Italy had their agencies in every Euxine harbor of any consequence. The Eurasian waterways had permitted the establishment of Italian commercial colonies on the coast of the Black Sea. Families claiming descent from Italian medieval settlers are found to-day in many harbors of ancient or modern importance.

If abundance of nomenclature on ancient maps be considered as expression of the commercial importance of a given region the names on the Black Sea coast preserved on medieval maps suffice to reveal the extent of trade relations between Italy and the Levant. The tonnage of Italian traffic with the East was derived not only from the important agencies like that of Galata founded by the Genoese within the present limits of Constantinople, but from numerous smaller posts and colonies scattered on the Black Sea coast.

The westerly spread of the Turks resulted in the gradual closing of the eastern waterways to Christian traders. In particular the control of the Dardanelles-Bosporus sea road by the Turks in the sixteenth century destroyed the most convenient avenue of intercourse between the prosperous Italian republics and their Black Sea colonies. From this time on trade relations between north-central Mediterranean ports and the Ægean and Black seas dwindled to insignificance on account of the restriction imposed by the Turkish government and the vexations to travelers caused by its officials.

The destruction of this Levant trade, however, did not end the demand of Europe for the products which the East had hitherto supplied. Spices consisting principally of pepper, cinnamon, ginger, cloves and nutmeg were still sought. The stocks of silk, gum, lacquer and certain perfumes and precious stones were being gradually depleted. These products now reached Europe intermittently and by way of southerly routes through Asia Minor, Syria and Arabia. The journeys to which traders had to submit were long and perilous. The result was that spices sold in Italian ports three or four times higher than in Calicut. Incense could only be obtained at six times its selling price in Mecca.

Furthermore, the scarcity of gold and silver was beginning to be felt acutely about that time in Europe. After paying its eastern purchases with the precious metals for centuries the west had reached the stage in which its supply of coins was failing.

These are some of the economic conditions which led to westerly explorations in the course of which America was discovered.

The consolidation of Ottoman dominion in Europe after the fall of Constantinople marked the highest development of the strategic value of the waterways. This feature was considerably enhanced by the introduction of artillery as an arm about that time. Prior to the establishment of the Turkish capital at Constantinople the strategic position of the straits had proved valuable in two important directions. For long it had acted as a natural moat defending European sections of the Byzantine Empire from Turkish attacks. In still earlier times and with the stronghold of Constantinople at its northern end the Eurasian ford had acted as the barrier deflecting barbarian invasions through Illyricum to Italy and the west. With armies and navies resting on the triple circle of Byzantine ramparts the narrow waterway was converted into a natural obstacle in the path of barbarian hordes which had succeeded in crossing the Danube in the course of recession from the northeast. Asia Minor, Syria and Egypt were thus spared the effects of the passage of invaders coming from the north.

The existence of the straits has profoundly affected the destinies of the Ottoman Empire. Turkey's disintegration marked by successive southeasterly recession of its European boundary was retarded considerably by the impregnable character of the defensive works constructed on the winding shores of the Dardanelles. This narrow strait attains a length of forty miles between the Ægean and the Marmora. A contracted channel, marked sinuosity of course and a line of hills on each shore commanding the intervening watery space provided all the elements which nature could bring together to form a fortress.

In modern times the waterway has played an important part in the rivalry between western and eastern nations for its possession. In particular, whenever the pressure of Slavic might tended towards a final effort to subjugate the Turk a convenient check could be promptly administered by an armed force sent through the straits to protect the Sultan's capital.

The international status of the waterway has been affected by its intercontinental location. As a section of an important world route its fate concerned every nation whose subjects made use of this highway. The long-deferred expulsion of Mongolians and Tatars from European soil can only be explained by the fact that the Turks descended from these races were the convenient masters of this important waterway. The occupation of this region by a power of the first mag-

nitude could not be tolerated by the other large nations in view of the menace constituted thereby to unimpeded transit of men and merchandise.

Expression of the tense political situation resulting from the importance of the site is given in the number of treaties forbidding the transit of armed vessels through the straits. Conventions signed by Turkey and European powers prior to the nineteenth century had closed the straits of the Dardanelles as well as the Bosporus to men-of-war. In the middle of the nineteenth century these agreements acquired validity as declarations of a principle deserving permanent application. An international conference, held in London, ratified on July 13, 1841, all previous agreements by the signing of a convention in which the Sultan bound himself to forbid access of the Dardanelles or Bosporus to foreign war vessels. The European signatory powers to this agreement were Great Britain, Russia, France, Austria and Prussia.[5] Since then the value of mastery of this watery stretch of an intercontinental route has acquired such proportion that the presence of storm-tossed war-vessels seeking refuge from the fury of the elements sufficed to raise vehement protests against their presence in the forbidden waters.[6]

To our own generation at a time when the economic importance of a region is the prime consideration affecting its world relation the gauging of the value of the Eurasian waterways must be determined by their central location with reference to the continents of Europe, Asia and Africa. Between Paris and Bagdad or Aden the overland route is continuous save for a short mile of water at the Bosporus. Here a bridge will undoubtedly connect the two continents in a day which can not be delayed much further. Man's achievement will thus have crowned nature's work once again. A minimum width of channel breaking the continuity of land along the northwest-southeast intercontinental road provided by nature is a requirement of modern conditions no less than it was in former centuries. Present exigencies differ, however, from the necessities of early days. Security had formerly been sought in the well-nigh unbroken stretch of land affording access from Europe to Asia, and vice versa. Rapidity of communication has now become the desideratum of greatest import.

Thus the advantages inherent in the site of the Dardanelles to Bosporus Strait determined its relation to humanity settled far from its limited area. A road is to a large degree the joint property of its users. The political status of the Eurasian waterways hence affects the inter-

[5] P. Macey, "Statut International des Détroits," Lechevalier, Paris, 1912.

[6] In October, 1849, a British fleet under the command of Admiral Parker while at anchor in Besika Bay was driven by a violent storm to seek shelter at Hauslar Bay in the Dardanelles. The incident elicited a protest from the Russian ambassador in Constantinople, notwithstanding the retirement of the English men-of-war to Besika Bay after the storm had subsided.

ests of the entire community of European nations. In this a determining factor is obtained which may lead to the eventual formation of an independent political unit formed by the elongated zone of coastland enclosing the Dardanelles, the Sea of Marmora and the Bosporus. The boundary of this territory in the Balkans, if made to coincide with the line determined for Turkey's western boundary at the Treaty of London of May 30, 1913, would conform fairly accurately with natural divisions. On the Asiatic side the valley of the Sakaria and a long fault line revealed by the lakes east of the Marmora provides ready-made frontiers which could be conveniently extended to the Ægean. This line had constituted the Asiatic boundary of the Latin Empire of Constantinople in the period intervening between the years 1204 and 1261. To-day the establishment of an internationalized area or neutral zone in this region would be an added instance of conformity to geographical principles observable in many sections of the world.

SOME PIONEERS IN MOSQUITO SANITATION AND OTHER MOSQUITO WORK

By Dr. L. O. HOWARD

BUREAU OF ENTOMOLOGY

In planning, as early as 1903, a monograph of the mosquitoes of North and Central America and the West Indies which should be of service to zoologists and sanitarians,[1] the writer included in his outline plan some consideration of the pioneer workers in this field, and with considerable trouble secured the photographs which are reproduced in this article. He well knew the interest which always attaches to the personalities of men who do great work, and felt sure that the publication of these likenesses would add greatly to the interest of the monograph. But when the monograph was completed and printing begun, he discovered that the Carnegie Institution of Washington had laid down a rule that the portraits of living men were not to be published in any of the volumes issued by the institution. This was rather embarrassing, since it had been definitely stated to the foreign workers that the photographs would be used in this way; but since this was impossible, it seems desirable to have them appear in accessible form, and it is with full confidence that the readers of The Popular Science Monthly will be glad to know what these men look like that these lines are written. During the four or five years following Ross's discovery of the carriage of malaria by certain species of *Anopheles* there was intense activity in many parts of the world in mosquito investigations, and it is the pioneer workers of this period who are here shown. The only very prominent worker who is omitted is Robert Koch, whose photograph I was unable to secure. The only Americans included are the original members of the Army Yellow Fever Commission, Dr. A. F. A. King, of Washington, Dr. J. H. White, of the U. S. Public Health Service, and Surgeon-General Gorgas, who during that period had accomplished his wonderful clean-up of Havana.

They are a fine, forceful set of men, as their faces show, and to this group the world for all time will owe much. Nearly all of them are, or were, known personally to the writer, and he can thus assure those who read this article that the faces of the men themselves are like their photographs.

[1] This work under the joint authorship of the writer, H. G. Dyar and Frederick Knab, has been completed. Two volumes have been published, and the final two will shortly appear, under the auspices of the Carnegie Institution of Washington.

SIR PATRICK MANSON

Sir Patrick Manson, F.R.S., K.C.M.G., M.D., LL.D.; late physician and medical adviser to the Colonial Office; distinguished as a pioneer investigator and teacher; author of a standard work on Tropical Medicine; the discoverer of the transmission of filariasis by mosquities; the man who suggested to Ronald Ross his investigations of the transmission of malaria by mosquitoes.

SIR RONALD ROSS

Major Sir Ronald Ross, K.C.B., M.R.C.S., D.P.H., Hon. F.R.C.S., LL.D., Sc.D., M.D., F.R.S., professor of tropical sanitation, University of Liverpool and Liverpool School of Tropical Medicine; physician for tropical diseases, King's College Hospital; member of many sanitary committees; commenced special study of malaria in 1892 and later definitely traced the relations between malaria and mosquitoes; has since made tropical hygiene his life study and has conducted investigations of the highest importance in many parts of the world. He received the Nobel prize for his work in medicine in 1902.

PROFESSOR GEORGE H. F. NUTTALL

George H. F. Nuttall, F.R.S., M.A., M.D., Ph.D., Sc.D., Quick professor of biology, Cambridge University, England; chief editor and founder of the *Journal of Hygiene* and of *Parasitology*; an eminent bacteriologist and parasitologist, who early studied the biology of the *Anopheles* mosquitoes of England, and who has written much of the carriage of diseases by insects. Dr. Nuttall is an American by birth and was educated at Johns Hopkins University, and later in Germany, where he lived for a number of years.

Dr. Arthur E. Shipley

Arthur E. Shipley, F.R.S., M.A., Sc.D., master Christ's College, Cambridge University; reader of zoology; co-editor of *Parasitology* and of the *Journal of Economic Biology.* A broad, general zoologist who collaborated with Nuttall in some of his early studies on malarial mosquitoes of England, and who has written much on the subject.

PROFESSOR FREDERICK V. THEOBALD

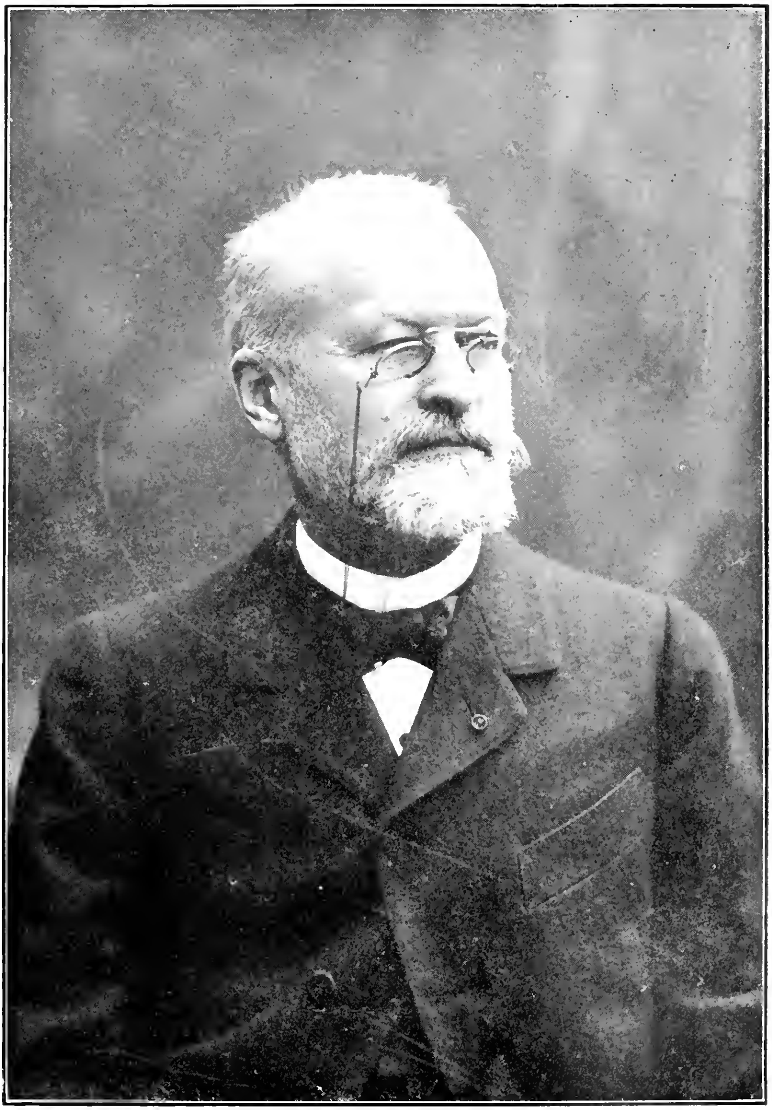
Frederick V. Theobald, M.A., vice-principal of the Southeastern College of Agriculture at Wye, Kent, England; professor of economic entomology and zoology; author of the five-volume monograph of the Culicidæ of the world, issued by the British Museum of Natural History, the first two volumes of which were published, with a volume of plates, in 1901, and afforded a convenient method for the determination of species to the early workers in the transmission of disease by insects.

PROFESSOR G. B. GRASSI

Professor Dr. G. B. Grassi, professor of comparative anatomy and entomology in the University of Rome, and director of the institute of comparative anatomy; a very famous man of many-sided accomplishments, who, with Celli, studied the relations of malaria and the *Anopheles* mosquito, and was the first to point out that while early experiments with the carriage of malaria by mosquitoes of the genus *Culex* were negative, they might be successful with those of the genus *Anopheles*, just as Ross in India failed with his initial work with *Culex* and succeeded with the "dapple-winged" mosquitoes of the genus *Anopheles*.

PROFESSOR ANGELO CELLI

Professor Dr. Angelo Celli, director of the institute of hygiene, University of Rome, Italy. He was, up to the time of his very recent death, one of the foremost living workers in hygiene. His investigations and those of his colleagues and students were almost simultaneous with those of Ronald Ross in India, and largely through his personal instrumentality malaria has been enormously reduced in Italy. The Roman Campagna has once more been made habitable and the health of the peasants has very greatly improved.



DR. C. L. A. LAVERAN

Dr. C. L. A. Laveran (ordinarily written A. Laveran), member of the Institute of France; member of the French Academy of Medicine; famous protozoologist; professor of protozoology, Pasteur Institute, Paris. He was the first to demonstrate the true cause of malaria and to describe the malarial parasite; is a very learned man in protozoology and has occupied himself much of late years with the subject of tropical diseases as they occur in the tropical and oriental French colonies.

PROFESSOR RAPHAEL A. E. BLANCHARD

Professor Dr. Raphael A. E. Blanchard (commonly known as Raphael Blanchard), professor of parasitology of the faculty of medicine in the University of Paris; director of the *Archives of Parasitology;* author of a standard two-volume treatise on medical zoology, and one of the most prominent figures in medical zoology to-day. He is the author of a large work on the natural and medical history of mosquitoes, published in Paris in 1905.

Dr. Edmond Sergent

Dr. Edmond Sergent, director of the Pasteur Institute of Algeria; a man who, with his brother Étienne, chief of the malarial laboratory of the Pasteur Institute of Algeria, has made a special study of malarial mosquitoes and has devoted years to the problem of alleviating malarial conditions in Algeria.

Professor D. Marchoux

Professor D. Marchoux, microbiological laboratory, Pasteur Institute, Paris (section of tropical bacteriology); head of the French Commission to Brazil, which carried on monumental studies concerning the yellow-fever mosquito in Rio Janeiro, making many important discoveries.

Dr. E. Simond

Dr. E. Simond, Pasteur Institute, Paris; was a member of the French Commission to Rio Janeiro, with Professor D. Marchoux, which conducted the magnificent investigations on yellow fever and the yellow-fever mosquito, and which confirmed the work of the U. S. Army Commission in Havana.

(*To be continued*)

THE MORAL DEVELOPMENT OF THE CHINESE

By Dr. FREDERICK GOODRICH HENKE
ALLEGHENY COLLEGE, MEADVILLE, PA.

THE political events which have transpired in China during the past two decades are symptomatic of profound social changes. Former changes of government had their origin primarily in a discontent with the reigning dynasty, without the further implication of a desire on the part of the people to participate directly in the government. When the ruling dynasty became corrupt and the oppression too severe, Heaven's displeasure was manifested, they thought, by allowing some powerful opponent to gain access to the throne and deliver the people. In case the new monarch was benevolent, he was gladly received and heartily supported. At the present time the educated people earnestly desire to take a definite hand in the changes; and there is an insistent demand on the part of Young China for an opportunity to take a permanent part in governmental affairs. These ideals have been but partially realized; but the general situation, of which they are a part, has aroused the interest of the civilized world, for they appear to indicate that China will, if given the opportunity, make a modern nation out of herself.

The ethical implications of the present movement are of outstanding significance, as they show that real moral advance is being made. An adequate understanding of this particular phase of the problem is best attained by a survey of Chinese moral development from the standpoint that genuine moral progress in any nation is dependent upon the advance from morality on the plane of custom and tradition to autonomous moral conduct.

The Chinese people may conveniently be divided into two principal classes, though the line of demarcation between them has never been drawn so hard and fast that it has not been possible for the individual to pass from one to the other. There are first the educated—those who read and understand the literature of the country, and who engage in some literary or official pursuit. Official standing has in the past very largely depended upon the literary degree held by the aspirant for office. In the second class are found the illiterate, who, because of their uneducated condition, have no knowledge of the literature of China, except such as they acquire indirectly. The leaders of China have come from the first class; the members of the second class, constituting a large percentage of the 426,000,000 of population, have been and are to-day living on the level of custom. Kueichu (custom) is with them a final authority, and when it is subject to alteration, as in the present period

of transition, the sanctions have been removed and confusion is apt to follow. For the Chinese of this class custom is followed, not because of the meaning that attaches to it, but because it is the established and recognized way of acting. The moral sanctions have grown out of a unique historical setting from which it is very difficult for the Chinese to dissociate themselves.

Of the earliest period of moral development little or nothing is known except by inference. The ancient past of China is enshrouded in myth and mystery,—a fact which, as is well known by students of history, is typical of all nations. This is the pre-historic period which is present both in the race and, figuratively speaking, in the individual. During this progress was made largely on an organic basis, or with conscious participation in the realization of certain immediate ends without further thought for the future.

The historic period begins definitely at 500 B.C., when Confucius collected, compiled and edited the chief literature of China.

> He took the records of remote antiquity, and sifted them, in such wise, however, as to exert in a most effective manner the influence of an editor, giving to the readers of all succeeding ages only that which he wished to produce its effect on the national mind.[1]

He was followed by Mencius (371–287 B.C.) about one hundred and fifty years later, who is known as the author of the "Works of Mencius." These two men and their disciples fixed the classic literature of China —the Six Classics and the Four Books—and by so doing determined the ethical conceptions of their people for over two thousand years.[2] From that time the educational ideal was not the creative production of independent literature, but the memorization and interpretation of the classic literature. In this way the classic literature of China took the same place in the development of China which the Vedic literature held in India. Serving as a standard, it frustrated that spontaneous development of thought which is a *sine qua non* of higher moral progress. Not only was the second class of people in China under the sway of custom, but the educated people and the leaders were also completely dominated by ideals that had been created centuries before. The enslavement to custom became complete, when the philosopher Chu Hsi (A.D. 1130–1200) of the Sung Dynasty fixed the interpretation of the classics by his commentaries. It was so thorough that signs of genuine liberation have been present for only about two decades, and even at the present time the majority of Chinese scholars accept the interpretation of the philosopher Chu without further question.

In addition to the restraining effect of the classic literature, the re-

[1] W. A. P. Martin, "The Lore of Cathay," Revell Company, N. Y., p. 170.

[2] The sixth Classic is the "Book of Filial Piety," which is sometimes omitted in the enumeration.

ligious teachings of Lao Tzu, the founder of Taoism, also discouraged individual initiative and thereby moral progress. The sage Lao Tzu, who was a contemporary of Confucius, found the great principle of life in the "Tao." This term "Tao" has an abstruse and mysterious connotation, having been rendered "Reason," "Nature," "The Universal Order," "The Way," "God." The following citation from the fourteenth chapter of the "Tao-Teh-King" will show the elusiveness of its meaning.

> Looked for but invisible, it may be named "colorless";
> Listened for but inaudible,—it may be named "elusive."
> Clutched but unattainable—it may be named "subtile."
> These three can not be unravelled by questioning, for they blend into one.
> Neither brighter above nor darker below.
> Its line, though continuous, is nameless, and in that it reverts to vacuity.
> It may be styled "the form of the formless"; "the image of the imageless"; in a word the "indefinite."
> Go in front of it and you will discover no beginning; follow after it and you will perceive no ending.
> Lay hold of this ancient doctrine; apply it in controlling the things of the present day, you will then understand how from the first it has been the origin of everything.
> Here indeed is the clue to the Tao.[3]

This "form of the formless" and "image of the imageless" is viewed as the creative, organizing principle of the universe, and should not be hindered in its working. Lao Tzu "discouraged above all the assertiveness by which any individual would attempt to magnify his importance or to interfere with the normal quiet and rational development of things."[4] The Tao-Teh-King says:

> The world's weakest drives the world's strongest.
> The indiscernible penetrates where there are no crevices.
> From this I perceive the advantages of non-action.
> Few indeed in the world realize the instruction of silence, or the benefits of inaction.[5]

These and other available passages from the "Tao-Teh-King" show clearly that Lao Tzu also made his contribution to a more complete enslavement to custom.

The introduction of Buddhism into China during the reign of the Emperor Ming-Ti (A.D. 58–76) did little or nothing toward stimulating a genuine development of the moral ideal. Buddhism in its inception and development has consisted almost entirely of methods whereby the individual may rid himself of the evil effects of desire. Its influence has

[3] C. Spurgeon Medhurst, "The Tao Teh King," Chicago, Independent Book Co., p. 24 f.

[4] Paul S. Reinsch, "Intellectual and Political Currents in the Far East," p. 123.

[5] C. Spurgeon Medhurst, "The Tao Teh King," p. 75.

been quite largely negative, for it takes men out of society. Abstract and monotonous contemplation according to definite rules is typical of its techniques. Such inwardness is fatal to the genuine autonomy of higher morality. So far from leading men forward into higher cultural life, it simply burdened them with further groups of customs. Owing to the fact that discrimination has not set in, large numbers, if not all, of the Chinese are at one and the same time Confucianists, Taoists and Buddhists.

In all this the ethical ideal which was emphasized by Confucius and interpreted later by the philosopher Chu has had a profound influence on the majority of the Chinese. It is succinctly expressed in the Great Learning in the following words:

> The ancients who wished to promote virtuous conduct throughout the kingdom, first ordered well their own states. Wishing to order well their own states, they first regulated their families. Wishing to regulate their families, they first cultivated their persons. Wishing to cultivate their persons, they first rectified their hearts. Wishing to rectify their hearts, they first sought to be sincere in their thoughts. Wishing to be sincere in their thoughts, they first extended to the utmost their knowledge. Such investigation of knowledge lay in the investigation of things.[6]

This descending series should be approached from below, so that it involves ascent rather than descent. Broad knowledge of self and others is the foundation, and upon this are built in succession sincere thoughts, rectified minds, practise of personal virtue, well regulated families, well ordered states, and finally the promotion of practical virtue throughout the kingdom. Such ideals challenge the admiration of all men and might well stimulate autonomic conduct. Unfortunately, as we have indicated, the whole series rested on a basis of convention, so that it was little more than mere form.

The situation is similar in the instance of the five social relationships—of husband and wife, father and son, brothers, prince and officer, and friends. They do not rest on a rational basis, but have become incrusted with layer upon layer of custom. An illustration or two will serve to elucidate this point.

In case of severe illness of a parent, there has been a generally held belief among the Chinese for thousands of years that a cure can not be effected, unless a piece of the flesh of the son is cooked and then eaten by the parent. Naturally cases of this sort are not everyday occurrences, but they have the sanction of custom and in extreme instances are adopted. References to this have frequently appeared in Chinese papers. Dr. Smith assures us that he has become "personally acquainted with a young man who cut off a slice of his leg to cure his mother and who exhibited the scar with the pardonable pride of an old soldier."[7] He also

[6] "The Great Learning," Introduction, p. 4.

[7] Arthur H. Smith, "Chinese Characteristics," New York, 1894, p. 178.

cites the experience of Abbé Huc. Having occasion to send a messenger, the latter thought that a Chinese schoolmaster who was working for him might desire to improve the opportunity to send a letter to his old mother whom he had not seen for four years. The schoolmaster, upon hearing that the messenger would leave soon, called one of his pupils, saying: "Take this paper and write me a letter to my mother." M. Huc was surprised and proceeded to inquire whether the boy was acquainted with the teacher's mother. Receiving a negative reply, he said: "How then is he to know what to write?" The schoolmaster answered: "Doesn't he know quite well what to say? For more than a year he has been studying literary composition, and he is acquainted with a number of elegant formulas. Do you think he does not know perfectly well how a son ought to write to a mother?"[8] The boy returned the letter to his teacher sealed, and it was thus forwarded. It would "have answered equally well for any other mother in the Empire."

The tremendous population of China is also largely the outgrowth of the requirement of Confucianism that the son shall worship at the grave of his deceased parents. No greater honor can come to a woman than to be the mother of a son. If she fails of this, she is not infrequently obliged to make room for another who can bear a son, for no man is content until he has a son who can worship at his grave. Until this superstition is brought under the light of reflection, excessive propagation will continue and with it moral development will be retarded.

But withal the situation is somewhat better than it would appear. Fortunately for China, agencies have been at work in the past that were operative in the right direction. Of these, we may distinguish both rationalizing and socializing forces. The value of these agencies as factors in promoting moral development depends largely upon their advancing *pari passu*. Rationalizing forces make for systematic conduct based upon natural law as a result of reflection and scientific control; socializing forces contribute to a more equal distribution of the concrete things that satisfy the health, wealth, sociability, knowledge, beauty, rightness, and religion desires of the human being. Two men stand out very prominently in Chinese history, previous to the present reform movement, as making a serious attempt to break away from custom and advance the moral condition of the Chinese. Their efforts were not crowned with success at the time, but they served to keep alive the spark of progress which was all but extinguished.

The first was Wang An-shih of the Sung Dynasty, A.D. 1055–1085. Realizing the poverty-stricken condition of his people in contrast to their prosperity under the sage emperors Yao and Shun and Chou Kung, he was very anxious to do something for them. The Emperor Shen-

[8] *Ibid.*, pp. 180, 181.

Tsung asked him one day, "If I were to make you chief minister of state, what would you do?" "I would change the customs and institute reforms," Wang replied.[9] Thereupon the emperor formed a board of three officials, whose task it was to investigate the condition of the country and to suggest where improvement might be made. This board sent out officers throughout the country "to report upon the nature of the soil, where watered and where not, where it was rich and where it was poor," and to give other information that might help to alleviate the condition of the farmer. The outcome of this movement was the introduction of four reforms:

1. The first was a state monopoly of commerce. The commerce of the country was to be carried on by the state instead of by the people. The plan is briefly summed up by MacGowan as follows:

> The taxes for the future should be paid in the produce of the district where they were levied, and the state should furnish funds to buy up what was left. This should be transported to different parts of the country where a good market could be found and sold at a reasonable profit. Thus would the state be benefited and the poorer classes be saved from the oppression of the rich, who had been in the habit of buying cheaply and selling at exorbitant prices.

This reform included a scheme for state advances to cultivators of the soil. The government loaned money to all farmers in the spring when the seed was sown, and a definite sum of money was returned in the fall by the farmers. These loans netted about two per cent. per month.

2. The second reform was an attempt to equalize taxation. To this end the country was divided into Fangtien, or square fields, one thousand steps on each side, and the taxes on each were appraised in the ninth moon, "according to the general average of the producing power of the soil, which was divided into five classes according to its fertility.[10]

3. The third reform measure introduced militia organization. Every ten families were organized into a group with a headman called a Paochang; five such groups, or fifty families, were formed into a larger group with a higher commander; and ten of the larger groups formed a district. All homes having more than one son were obliged to give one in service to the state. The members of the militia were allowed to remain at home in time of peace, but when war or disturbance threatened they were called out by the headmen. Modifications of this reform were later used in the Ming and Tsing Dynasties.

4. The last of the great reforms of Wang An-shih was that of providing for the construction of public works by means of a family tax. He wished to remove the abuses that grew out of compulsory labor. His plan was to rate the tax required in accordance with the property of the fam-

[9] J. MacGowan, "Imperial History of China," Shanghai, 1906, p. 383.

[10] John C. Ferguson, "Wang An-Shih," an article in the *Journal of the North China Branch of the Royal Asiatic Society*, Vol. 35, p. 72.

ily. The method which was devised to secure accurate information for this purpose caused great confusion and misery.

On the whole, Wang An-shih's attempted rationalization and socialization of conduct was not successful. He was unwise in some of his efforts, and was vigorously opposed by Sz-ma Kwan and other prominent officials at the time. Nevertheless, certain permanent benefits from his reforms came down to later generations, and, what is more, his effort remains as one of the outstanding attempts to break the shackles of custom.

A second great moral reformer who broke with custom was Wang Yang-ming, or Wang Shou-jen. He inculcated doctrines which have had a profound effect upon the Japanese during the past one hundred years, and which are to-day wielding a great influence upon the Chinese mind.

The date of Wang's life is approximately 1472–1528.[11] As compared with contemporary European history, he lived in the period of the great maritime discoveries and at the beginning of the Reformation. He was fearlessly propounding his views in China shortly before Giordano Bruno, after a life of restless wandering in search of truth, suffered martyrdom for his philosophic exposition of the universe, and about a century previous to Hobbes, Descartes and Spinoza.

The most important thing about his philosophy is that it does not unreservedly advocate the interpretation given to the classics by former scholars, but insists on a rationalization which gives room for progressive adjustment. For him, human life, both in the race and in the individual, was a developing thing. He insisted that the highest values of life are realized only through development, and that apart from development life must prove a miserable failure. That he failed to approach the problem from the modern scientific view does not detract from the fact that he actually got a glimpse of the developmental character of human institutions, and that such a standpoint will invariably result in moral progress if thoroughly assimilated.

The one sentence, "My nature is sufficient," gives the foundation upon which the whole structure of his philosophy and ethics rests. Man's mind holds the key to all the problems of the universe. Nature—experience, we would probably say—is the stuff out of which the universe is made. This nature may be viewed from different aspects, but in whatever way it is approached, it is just this one nature.

> Referring to its form and substance, it is Heaven; considered as ruler or lord, it is Shangti (God); viewed as functioning, it is fate; as given to men, it is disposition; and as controlling the person it is mind; manifested by mind it is called filial piety when it meets parents, and loyalty when it meets the prince. Proceeding from this on, it is inexhaustible, but it is all one nature.[12]

[11] Vide *Monist*, Vol. XXIV., No. 1, p. 17 ff.

[12] Wang Yang-ming, "Philosophy," Book I., p. 23. This reference is to the Chinese edition published by the Commercial Press, Shanghai.

If nature at large be designated as the macrocosm, then human nature is the microcosm, and for Wang human nature was the human mind. He was taking recreation at Nanch'en, when one of his friends pointed to the flowers and trees on a cliff and said, "You say that there is nothing under Heaven outside the mind. What relation exists between my mind and those flowers and trees on the high mountain, which blossom and drop of themselves?" Wang replied: "When you cease regarding these flowers, they become quiet with your mind. When you see them, their colors at once become clear. From this you can know that these flowers are not external to your mind." This is undisguised idealism, in which the microcosm creates as truly as does the macrocosm. In the great all-pervading unity of nature the most differentiated, highly specialized portion is the human mind. It manifests the only creative ability that man can really know. Wang said again and again that it is *ab initio* law, that it is the embodiment of the principles of Heaven. Thus its very essence is natural law; but not in any partial, superficial sense. There are no other principles operative anywhere, for the mind is so all-embracing that it has no internal and external.

The influence of this point of view upon Wang's ethical theory and practise was profound. He held that it is not necessary to go to the classic literature to get a knowledge of fundamental ethical principles, for the human mind has these principles within itself. Intuitive knowledge of good is to be identified with moral principles. He who would have accurate information regarding right and wrong can get it from the intuitive faculty. The highest good consists in developing it to the utmost. It is to the details of right and wrong and to changing circumstances as compasses and squares are to squares and circles, and measure to length and breadth.

> The changes in circumstances relative to details can not be determined beforehand, just as the size of the square or the circle, and length and breadth can not be perfectly estimated. But when compasses and squares have been set, there can be no deception about the size of the circle or the square, and when the rule and measure have been fixed there can be no desception about length or shortness. When the intuitive faculty has been completely developed, there can be no deception regarding its application to changing details.[13]

Wang is to-day read extensively by Chinese students, and will probably influence the Chinese as much as he has the Japenese. He has the advantage over many other rationalizing and socializing forces of the present day in that his point of view is a direct product of the Chinese mind and therefore strikes a sympathetic chord in the mind of the Chinese scholars. As a rationalizing and socializing factor in the development of Chinese morals it exhibits the following doctrines:

[13] Wang Yang-ming, "Philosophy," Book III., p. 61 f.

1. Every individual may understand the fundamental principles of life and of things, including moral laws, by learning to understand his own mind and by developing his own nature. This means that it is not necessary to use the criteria of the past as present-day standards. Each individual is able to determine for himself what is right and wrong. Like Protagoras among the Greeks, Wang Yang-ming among the Chinese held that "Man is the measure of all things."

2. On the practical side, Wang taught that every individual is under obligation to keep knowledge and action, theory and practise together, for the former is so intimately related to the latter that its very existence is involved. There can be no real knowledge without action. The individual has within himself the spring of knowledge and should constantly carry into practise those things that his intuitive knowledge of good gives him opportunity to do.

3. Wang taught that heaven, earth, man and all things are an all-pervading unity. The universe is the macrocosm, and each human mind is a microcosm. This naturally leads to the conceptions, equality of opportunity and liberty, and as such serves well as the fundamental principle of social activity and reform.

Turning to the present reform period, we find two further types of forces at work in the moral development of the Chinese. Of these the first is the work of the modern Chinese reformers, and the second the impact of outside influences upon China. While these are discrete in certain aspects, they coalesce at many points. The ends sought do not differ greatly. The Chinese reformer of the present day recognizes the value of occidental techniques and of the principles of our civilization. This entails a rationalization and socialization of conduct which destroys the value of many Chinese customs and stimulates reflection on problems of conduct.

Among the principal Chinese reformers of the last two decades we may name K'ang Yu-wei, Liang Ch'i-ch'ao, T'an Ssu-t'ung, Dr. Sun Yat-sen and the men associated with them. Almost from the first their object was to rid China of the abuses of an absolute form of government. K'ang Yu-wei, Liang Ch'i-ch'ao and T'an Ssu-t'ung were intimately connected with the "hundred days of reform" and the "coup d'état of 1898," when an attempt was made to inaugurate a milder, more liberal form of government. T'an was executed the same year, while K'ang Yu-wei and Liang Ch'i-ch'ao escaped. Dr. Sun was connected with a movement in Canton against the government in 1895, as a result of which he became a fugitive. He returned to his country in the autumn of 1911 and became Provisional President of China and a prominent member of the People's Party (Kuo-ming-tang). These men and their associates have done much to awaken an interest in republican principles of government, social reform and individual initiative. Liang

Ch'i-ch'ao has been Minister of Justice under President Yuan Shih-kai and also editor of the *Yung Yen Pao* ("Justice"), published in Tientsin twice a month. K'ang Yu-wei carried on reform work from Japan. All of these men had high ideals for their country—ideals which have been but partly realized owing to the condition of the masses of the people and to official opposition.

As far as the impact of outside influences is concerned, western education has been a strong factor in showing that the old ideals and techniques are inadequate, as compared with those of western countries. Students have gone to England, Germany and America, and have had ocular demonstration of the prosperous social and economic condition of the people there. They have seen democratic principles practically applied; and the fundamental principles of western civilization, as well as the scientific attitude toward the problems of life, have been acquired by them in the colleges and universities. Returning to their country, they have by example and precept promoted individualism and social justice. Some have gone to Japan and have seen what great changes are taking place under the influence of the modern movement there. Other students, upon entering schools established by Europeans and Americans under the supervision of various missionary societies, have become acquainted with western ideals for the individual and society. They, too, have taken an active part in propagating ideas that stimulate advance from custom into reflective morality. The influence of these factors, and the sad experiences of the Boxer uprising, were so pervasive that Tzu Hsi, the Empress Dowager, upon the advice of Yuan Shih-kai and Chang Chi-tung, issued a decree in 1904 abolishing the old system of examinations and making graduation at one of the modern colleges the only recognized path to official employment. The abolition of the old system of education and the introduction of new ideals in the schools throughout China was one of the principal causes of the overthrow of absolutism and the founding of the Republic. And since the founding of the Republic, the old conception of the education as an instrument for making loyal subjects of the Emperor has, according to the ministry of education, been changed into an attempt to utilize education as a means of cultivating moral and virtuous character for the purpose of qualifying both men and women for citizenship.

The commercial relations existing between China and foreign countries since the forced introduction of opium have also furthered the moral development of China. The development of commerce, industry and art affects the moral life in three important ways. (1) "It gives new interests, and opportunity for individual activity."[14] (2) These increased opportunities bring forward the question of values. Are all the new activities good? If so, what can be done to promote them?

[14] Dewey and Tufts, "Ethics," p. 153.

If not, what shall be done to hinder their progress? (3) The development of commerce raises the question of distribution. Are the goods distributed in a just manner? Are all the people of the country receiving their equitable portion? Manifestly the introduction of modern commercial and industrial methods will in time involve a tremendous change in the economic life of the Chinese. There are indications in China to-day of the beginning of an industrial revolution similar to the one in Europe in the second half of the eighteenth century. Railway transportation of commercial products has affected thousands of wheelbarrow coolies. The introduction of cotton and wool clothing has thrown large numbers of silk weavers out of employment. Modern machines are rapidly being introduced in the larger and more accessible cities and will soon follow in all parts of the country. Situations of this sort give rise to urgent moral problems and result in moral advance.

While educative and commercial forces have been operative, the introduction of Christianity into China through missionary enterprise in chapels and hospitals, has also greatly furthered moral progress. Christianity has called attention to moral evils and has created a sense of sin and unworthiness which has helped many to break away from pernicious customs. It has engendered a more adequate appreciation of the ideals of brotherhood and social justice and thereby has stimulated new conceptions of the relation of man to man, and of mutual responsibility. It has emphasized the worth of the soul, and in so doing has given added worth to individual life. Thousands have accepted the principles of Christianity—some consciously, other unconsciously. Many of these—especially women—have been encouraged to learn to read, and the ability thus acquired has served not only the immediately desired end of reading the Bible, but has also widened the intellectual horizon and created new and larger interests. Christianity has probably done more during the last hundred years than all other forces combined to liberate Chinese women from the shackles of custom.

China has entered a period of transition comparable to the period of the Sophists of ancient Athens, the Renaissance and the Reformation in western Europe in the fifteenth and sixteenth centuries, the industrial revolution of the eighteenth century, and the French Revolution. Old landmarks are being swept away; foot-binding will probably never reappear, and it is highly probable that opium will be effectually driven from the country. But certain old landmarks will be reinstated —in a modified form, perhaps, though not necessarily. At a feast given in the city of Nanking shortly after the formation of the Provisional Republic of China, one of the prominent officials of Sun Yat-sen's government informed the guests that "Confucianism is forever dead." Since that time it has received official recognition from President Yuan Shih-kai, and the titles and privileges which the lineal descendants of

Confucius had enjoyed under the Manchu dynasty, including the title of "Holy Duke," have been restored. China will not make the transition from customary morality to reflective morality in a few years, nor can a truly republican form of government be established there prior to a general rise of educational conditions. Japan awoke from her sleep in 1854 as a result of the coming of Admiral Perry, and soon thereafter instituted a campaign of reform. The Japanese have now become aware of the fact that they confront a great problem, and are to-day in the very act of discovering and confirming rational standards of conduct. Custom and reflection are waging mighty battles there to-day, for the modern movement is in full swing. In China the rational and social forces which have been set in motion should be allowed to operate until that great country has taken the necessary step from customary to reflective morality and has taken its place among the nations of the world.

WATER CONSERVATION, FISHERIES AND FOOD SUPPLY[1]

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A National Problem

No subject of national economy has broader significance to-day than that of water conservation. Every one knows that unrestrained floods wreak yearly an enormous destruction of property. Our flood losses have, indeed, been computed at 200 millions of dollars per year. All are aware that the demands of power are contributing to the gradual exhaustion of our coal deposits, while the possibilities of deriving power from the flow of water remain at our grasp. A single water power of recent development has been estimated to effect a yearly saving of 365 thousands of tons of coal even at the very outset of its operations. Every intelligent conservationist, whether farmer, business man or student, observes that over the country-wide the soils are being impoverished by the wash of surface waters, and the fertile lands are being carried away to enrich the sea. If we seek figures again, we are told that one and one-quarter billion tons of silt are deposited annually in the Mississippi River, one half of which serves to impede navigation and the other half to extend the state of Louisiana out into the Gulf of Mexico. One who has observed the soils of the middle west in a state of productivity, and again the same or similar soils in the form of useless and rapidly broadening flats at the tip of the delta of the Mississippi, can not but be deeply impressed with the ultimate wastefulness of permitting the transfer of soils from a place where they are useful to a place where they are injurious.

If we view only the most obvious losses, we begin to realize the significance of water conservation; but still we may be far short of comprehending the magnitude of the forfeit that we regularly pay for an inadequate policy or practise with regard to our supplies of water. While agriculture, and consequently the flood supply of the future, may suffer from the erosion and leaching of soils, economists assure us that there are immense areas of farming lands which are diminished in production, because at the critical season they lack the moisture that might, with different methods of tillage, have been conserved in the soil from

[1] Published by permission of Dr. Hugh M. Smith, United States Commissioner of Fish and Fisheries; the author alone is responsible for the opinions expressed.

the time of water surfeit.[2] Again, while rivers become torrential and destructive, submerging valuable farming lands and taking a toll of property and lives, yet, because the spring waters were allowed to pass quickly away unstored in soils or reservoirs, these same streams at other periods are found to be so restricted in volume and so checkered in course by accumulated drift that the pathways of natural transportation are more or less effectively closed.

It is clearly within reason to say, then, that no other form of material waste can be measured against the stupendous aggregate resulting from the failure to conserve and control and utilize the available supplies of water. It is easy to understate the importance of water conservation, while overstatement would almost seem beyond our powers. Water-power development and the conservation of coal deposits, soil conservation and the reclamation of arid and semi-arid lands by irrigation or by "dry-land" methods, reforestation and flood control, reclamation of overflowed lands and maintenance of inland waterways, stream pollution and fisheries—these several objects, each of great importance by itself, are all, in large measure, aspects of the one comprehensive problem. Each of these admitted obligations has a direct relation to our duty of storing the available water supply in soils or in reservoirs, of regulating its flow from source to sea, and of utilizing it to the maximum at all stages, for power and navigation, for farms and forestry, for sanitation and fisheries. Stated in this way, with all its manifold bearings, the general problem may assume an exaggerated appearance of complexity. Surely water conservation is broad in its relations, and surely its complete realization will not be attained in a day or in a generation, and yet the stages of the solution of the entire problem may be just such matter-of-fact steps as we are repeatedly taking in the ordinary course of practical progress.

Fisheries have been named just above as related to water conservation. The relation might be obvious and yet insignificant: this may be called the prevailing impression. Fresh-water fisheries have been practically entirely disregarded in connection with the conservation of water; nevertheless, it can, I believe, be made apparent, first, that the possibilities of food-supply from fresh-water fisheries in public waters will be realized only as water conservation becomes a reality, and, second, that the proper development of fish-raising as a principal or incidental occupation may, in a very practical and simple way, promote the general object of water conservation.

2 Wall, Judson G., "Flood Prevention and Its Relation to the Nation's Food Supply," *Science*, N. S., XL., No. 1019, pp. 44–47, July 10, 1914; signed as chairman of the committee on soil erosion of the Social and Economic Section of the American Association for the Advancement of Science. A strong and suggestive paper, but without mention of fisheries.

Fisheries, a Matter of Concern

It is not very difficult to understand why the fisheries so rarely receive mention in discussions of water conservation. In the general mind, fresh-water fisheries do not rank with the bases of industry so much as with the means of recreation. Some industries assert themselves by figures, but, in the way of statistics, the fresh-water fisheries have not the striking appeal of established agricultural industries: statistically speaking, we can not now compare fish with potatoes. Primarily, however, people do not think of fisheries in connection with water conservation, because it is not generally understood that the two have a connection worthy of consideration. It is worth while to inquire if there is a relation of real significance.

The value and the meaning of the fish resources to the people of the United States depends upon the contribution of an important element of food supply and the offering of a peculiar field of recreation. Perhaps, in the mind of the average man of this country, the one benefit would be regarded in equal measure with the other. This is not an inevitable or universal condition; it is an incident of the present state of the fishery. There are countries where the taking of fish for sport is almost unknown, but where the fish resources are regarded as of vital moment to the welfare of the people, and where the capture and the preservation and the distribution of fish are industries that are recognized to be of elemental importance, in similar fashion to agriculture. In many other counties fish forms much more of a staple food than with us, and a far larger proportion of the people find a livelihood in the fishery industries. Our people are not essentially different from others in their appetites and bodily needs.

The basic claim of fisheries to public recognition rests upon the part that fish must play in the future food supply of the country; but how is it to be said what this future part will be? Certainly the future is not to be measured by the present. We know that the fisheries of our principal streams are in a state of depletion except in rare localities, and we know, though we are much less conscious of this fact, that the compensatory development of commercial fishery resources in the rivers, by artificial propagation or by other well-directed means, is relatively slight. Nearly all of our thought, all of our energies, all of our expenditures, have been directed to promote the abundance of game fishes, and perhaps we might have to confess that we were thinking not so much of providing something to eat as of supplying something to catch.

A little reflection, a little common sense, will suggest to us that neither the present nor the past condition of the interior fisheries foreshadows the future. As our country becomes more thickly populated, as the capacities of the lands become more and more severely taxed, as the prices of meats mount higher, it is inevitable that we shall look

more to the possibilities of our waters to supply us with food. The true fish conservationist should look forward to something more than the preservation or the protection of existing fisheries: in fact, his ideal may well be a development of fishery resources that is now scarcely conceived in the public mind. We do not want, in fisheries, a restoration of the past, but the inauguration of a future.

Floods and Fishes

On every hand there are explanations of the diminution of the number of food-fish of the rivers; but surely this can be ascribed only in part to the causes of over-fishery or to other direct acts of man. One ultimate explanation, it may be confidently stated, will be found in those very conditions which have indirectly affected the flow of our great streams in so disastrous a way as to create a demand upon the government for the storage of waters and the regulation of the flow of streams. Deforestation, denudation, drainage—to these causes, among others, are ascribed the extreme flood conditions ensuing upon the development of the country, and to these likewise may be attributed a significant change in the condition of our rivers as bearing upon the natural reproduction and sustenance of fish.

The occurrence of spasmodic floods, of comparatively short duration and separated by intervals of extreme low water, have a deleterious effect upon fish life in manifold ways. The first realization of this fact comes with the observation of enormous numbers of young fish left in the overflow ponds isolated by the recession of the flood. The significance of the observation is not in any way grasped if we suppose that these innumerable fish were simply carried out by chance and left by a similar chance. The real phenomenon is this. The flood occurred when the breeding fish were seeking the shallow and warmer waters for the location of their nests and the deposition of the eggs. When the young from these eggs, together with the adults, are left to starve and suffocate and die in the disappearing or diminishing pools, we see, not the loss of a random proportion of the fish life of the stream, but the actual decimation of a generation. Consequently, it should be esteemed of high importance to reclaim and restore to the rivers the fish thus abandoned otherwise to destruction. Such overflow ponds are now, to be sure, a common source of supply for government and state departments seeking fish for general distribution. It is better that the "lost" fish should be used for some good purpose, rather than left to die, but, that our impression may not be confused, it should be remembered that the conservation of fish in the particular stream is regarded and promoted only in so far as the greater part of the fish are returned to the river, and this is done in some cases.

It may not and does not always occur that the flood comes just before the fish have begun to nest. It may occur while the eggs are yet

unhatched, and where they have been placed in favored locations along the shores of the streams at low stage. We may then only guess at the destruction which must ensue when the entire condition is suddenly and drastically altered by the untimely arrival of the flood. Clear shallow waters, warmed by the sun, are in a brief space of time replaced by deep and turbid torrents, and the very banks and bottoms are torn away or displaced. To fish life another catastrophe has occurred.

It will not be maintained that any practicable scheme of control, however comprehensive, will prevent altogether the occurrence of high and low stages, but it has been attempted to show that the regulation of the flow of rivers has a very direct relation to the reproduction of fish.

Without successful reproduction we certainly can not have fish; but the abundance of fish, even under natural conditions, does not depend alone upon successful propagation. The young fish must survive and grow, and for these ends their requirements are similar to those of other animals, namely, food and oxygen, principally. Likewise, just as in the case of other animals, the food is derived ultimately from the essential chemical constituents through the intermediation of plants. The rains that wash the soils bring the needed constituents into the streams, but not necessarily in a form available for animal life; for them to become available requires time, sunlight and vegetation.

It is clear that excessive turbidity and extreme conditions of flood have the most direct bearing upon the conditions of food supply for fish. Not only is this the case, but extreme low stages may have a highly deleterious effect. The first result of the decomposition of organic matters brought into the water is the exhaustion of the oxygen supply, and this may proceed to such a point as to make the environment distinctly unfavorable for any form of aquatic animal life. The beginning of mortality among the animals, whether smaller or larger forms, by adding to the amount of decomposing material, only serves to increase the rate of deoxygenation of the water and to accelerate the course of destruction. Such a catastrophe can be checked or restricted as to its duration or territory of action only by the development of sufficient plant-life to effect a restoration of equilibrium, or by the diluting and cleansing effect of an increased flow in the stream. Some of the instances not infrequently reported of enormous mortality of fish in portions of rivers just below cities and in times of low water are most certainly due to this very fact of a disturbance of the established equilibrium between sewage, plants and animals, with a consequent mortality that is self-accelerative to the point of inducing a conspicuous catastrophe.

Conservation of Favorable Environments

There has been developing in recent years almost a new science which deals with the gas-content and the chemical analysis of water,

as affecting the value of the water as a habitat for animal life. Surprisingly interesting observations and inferences have been made, but nothing has been learned to gainsay the statement that, to realize anything like the potential abundance of fish-life in our streams, it is necessary to approach more nearly to a condition of stable equilibrium. The primary difference between a natural stream or pond and an artificial fish-cultural pond is that in the latter the conditions are relatively stable and subject to a degree of control.

It is not to be supposed that water-power development has no relation to fisheries except as expressed in the presence or absence of a fishway. It may be inferred from what has previously been said that artificial pools at intervals in the course of a stream, entirely apart from the question of fishways, may bring substantial advantages in providing relatively extensive feeding and breeding grounds for fish, in affording conditions of relative stability, and in tending indirectly to make more uniform the conditions prevailing in the streams below or between the pools.

It becomes increasingly clear that all matters affecting the flow of streams have the most vital bearing upon the promotion of fishery resources, as touching reproduction, nourishment and respiration.

The artificial propagation of fish, even under present conditions, is producing results of significant value; but it is no disparagement of such operations to venture the prediction that the future will show that the effective conservation of fishery resources depends upon the coupling of intelligent fish-culture with comprehensive and well-advised conservation of the environment favorable both to the natural propagation of fish and to the multiplication of the essential elements of food supply.

The requirements of reasonable brevity prevent our enlarging upon the relation of fisheries to the various other phases of the general scheme of water conservation. Just a few suggestions may be ventured. It has been advocated in at least one state that the reclamation of overflowed lands should be so administered as not to eliminate entirely the favored breeding grounds of many species of fish. It would seem possible so to coordinate the two objects of retaining "fish-preserves" and providing lateral storage basins for flood waters as to promote simultaneously the conservation of fish and the prevention of floods.

In the irrigation fields of the west, it appears that there is not only a neglect of the possible advantages for fish life, but an unfortunate waste of the existing fish resources, owing to the want of suitable protecting screens in the irrigation laterals. The opportunities and the needs are not, however, unrecognized, and the subject receives serious consideration in some of the states concerned.

Stream pollution by sewage or industrial wastes has the closest re-

lation to fishery problems. Under some conditions a degree of stream pollution may prove distinctly favorable to the abundance of fish: in other cases it is unequivocally injurious. If the matter is one of significance to the fisheries, it is certainly true, on the other hand, that the problem of stream pollution, in its phases of ordinary interest, can not be studied to a definite conclusion except through analyses of the effects of the pollution upon the living aquatic organisms. This is to say, that the study of the sanitation of our streams involves the investigation of the effects upon fish or upon the organisms constituting the food of fish.

The dredging of channels and the construction of wing-dams as aids to navigation exert an unmistakable influence upon the distribution of fish and affect the fortunes of their existence in more or less obvious ways.

The conservation of water upon the farm remains for our consideration; but, if we may be permitted to draw a conclusion at this stage, it is this:— Whether we deal with head-water reservoirs for the regulation of stream flow, with water-power development and the incident pools, with reclamation or irrigation projects, with the dredging and damming for navigation purposes, or with stream pollution by any means, we find a vital relation to fishery problems and to fish-cultural operations. We find also a real necessity for the accumulation of a sufficient store of knowledge regarding the habits of fish, their requirements for feeding and breathing and breeding, and how these requirements are affected by the conditions that may prevail in our streams, lakes and ponds. We need, in short, an effective fishery science.

Water Storage and Fish Culture

We have already expressed the belief that the relation of fishery development to water conservation is not one of dependence only, but one of reciprocal benefits as well. It must be clear that we are speaking of development, not by protection, but by conservation of fish, with all that the term may imply. The word itself is unavoidably repeated frequently in such a discussion, because "conservation" alone seems to embody the whole thought of increase in supply along with development in utilization, as opposed to hoarding or restriction in use.

Could we think of an agriculture based upon protective measures? Could we imagine a modern nation dependent upon corn and cattle and poultry growing wild? Suppose a series of limitations for the perpetuation of crops and stock-yield, similar to the familiar measures for the preservation of fish or game; no scythe to have a blade more than 3 feet long, no individual to take more than 500 ears of corn per day, or to kill more than 10 pigs or 5 sheep or 2 cows per year. The very suggestion has a touch of absurdity: and yet such is the present

stage of our civilization or industrial life, as regards the utilization of fish. Not only may we question if this condition is permanent and inevitable, but we may be sure that the time will come when we will want fish to eat much more generally than now, and will get them by raising them in a larger way than is now done. We may have a familiar science of aquiculture just as we now have one of agriculture. It is interesting to note that, at the present time, there are sections of the country and classes of people for which fish forms a really staple food. This demand is so reflected in the commercial fishery that the coarser fishes, which, only a little while ago, were regarded as entirely superfluous or obnoxious, have become the mainstay of the commercial fishermen. It is still more interesting to observe that, among all classes of people, there is a noticeable awakening to the value of fish, and, concomitantly, a tendency to inquire if there is not some way to increase the supply of good table fish.

Let us now imagine that a great impetus could be given to the rearing of fish for table use as an occupation or as an adjunct to ordinary farming operations, until the fish pond were half as familiar as the poultry yard, and then let us inquire if there would be any effect upon the matter of water conservation.

The objects of flood prevention and navigation may be furthered in a temporary way by the construction of levees, by restriction of channels, and by dredging. All of these means are good; in fact they are essential for immediate relief; but the final accomplishment of the desired ends must be sought in the regulation of the flow of the rivers, and this undoubtedly will come about through the conservation of water at the sources. We sometimes think of this as being possible of attainment only by the construction of large artificial storage reservoirs at enormous expense, and often such a plan is called impracticable. Leaving that question, as we must, to the engineer, we may look to other and smaller measures which are certainly not impracticable. Smaller measure, we say, but we know that the cumulative effect of innumerable small efforts may in the long run be vaster than that of more spectacular and expensive operations.

It is said that much can be accomplished by the proper methods of tilling the soil to prevent run-offs and to compel the filtration of the rainfall into the soil. We are told of large farms that are so worked as to prevent any water at all running off the farm, while at the same time increasing the productivity of the farm with its cultivated fields, grazing lands and forests.[3] The methods are said to be simple and inexpensive, but an inquiry into them is apart from our present purpose.

Besides increasing the absorbent qualities of the soil, there is something which almost every farmer can do, that relatively few now

[3] Wall, Judson G., *loc. cit.*

think worth while. He can make one or more ponds in which much of the surface water is caught and stored for the subsequent use of his animals, and he can stock this pond with fish for domestic use, or for the market.

On the one hand, what a considerable addition to the food supply of the country would be found in such productive ponds. We are told of the fabulous wealth represented by the American hen,[4] and so it may yet be with the American catfish, the buffalo-fish, the sunfishes, or the bass. There is much to indicate that one can raise fish with less trouble and with as much profit as one rears poultry.

On the other hand, if one third of the 6,000,000 American farms had one or more fish ponds, what an enormous amount of water might be temporarily stored in these. It would seem that a positive step of some value would have been taken to prevent the destructive floods, to make more uniform the flow of streams, and thus to better navigation and to keep the soil waste upon the farm. "A fish pond for every farm" might yet become the watch-word for every advocate of improved navigation, flood prevention and soil conservation.

Some Practical Steps

It should not be presumed that a fad is proposed or that a simple nostrum is advocated for the immediate accomplishment of nation-wide benefits. Avenues of progress may be opened without calling for a headlong plunge into them. The incline is upward and probably beset with a common number of obstacles and pitfalls. On the one hand, if fish conservation in public waters can be promoted by broader and more positive efforts than are now generally made, it is necessary that thought and investigation should be applied to distinguish with certainty the ways that are right from the ways that are wrong. On the other hand, if increase of fish through private enterprise is practicable and appropriate, the movement will be but faintly advanced by the mere waving of a banner or a summons to the line. The imprudent are easily induced, but in the field of industry, the better recruits are the wise who look for plans and specifications and consider costs and possible returns.

There are many persons now seriously interested in fish rearing and who want to start a fish pond, or, having one, to make it more productive. They ask for information as to the fish and the conditions; but, at the best, the practical data that government or states can give

[4] American poultry products alone are worth half a billion dollars a year: report of Secretary of Agriculture, D. F. Houston, as quoted in the *Review of Reviews*, March, 1915, p. 266. This figure is more than double that of the potato crop, and approaches the estimate of value of the wheat crop. With the product of 500 millions from domestic poultry, compare the few millions (about twelve) credited to fresh-water fisheries, and based almost entirely upon wild fish.

is meager as bearing upon the questions raised. Few efforts for public service would be so apt and so inexpensive in proportion to probable return as the systematic dissemination of information bearing upon fish farming: but the data must be based upon judicious and continued experiment under conditions such as would confront the prospective fish farmers.

Doubtless a great deal of experience has been gained by private persons with interest and initiative, but there has been lacking a clearing house. There are valuable bits of information isolated or scattered and wanting for complete fruitfulness the benefits of interchange of experience, coordination and compilation. It would be practical indeed if the persons interested in effective fishery development would form themselves into associations, limited in territory by the similarity of conditions and problems as well as by the requirements of distance. The advantages to be gained would be palpable; there would be not only a fruitful interchange of ideas and experience, but a more explicit definition of difficulties and problems, so that the public department whose responsibility is to serve would be enlightened as to the form of service required.

The present purpose is fulfilled if the meaning of fish conservation is made clearer, and if the science of fisheries has been related in an unmistakable way to the vital interests of our whole people. The fish conservationist should orient himself with reference to some of the multitudinous phases of human interests and endeavors, and it is equally desirable that his orientation should be understood. One may look far over a landscape with the feet yet firmly upon the ground. A distant goal is not usually to be reached except by a succession of well-ordered steps, but perhaps it is also true that the farther the vision extends, the more readily may the steps be well ordered to the desired end.

THE PROGRESS OF SCIENCE

THE REPUBLIC OF LETTERS AND OF SCIENCE

THE importance of maintaining good will between the scientific men and the men of letters of the different nations is so great that we are glad to have the opportunity of printing here the remarks made by Professor Heinrich Morf at the opening of his winter course at the University of Berlin. As translated for us by Miss Agatha Schurz, Professor Morf said:

"On the morning of the first day of August I closed these lectures on the history of French literature. All hope of preserving peace had not yet vanished at that hour, and I belonged to the optimists. My optimism, however, was put in the wrong by the course of events, and we are now living in a state of war.

"The terrible conflict of arms is also a conflict of minds. Who could pride himself—if, indeed, it were a matter of pride—on having preserved his perfect composure! Even those who are not directly involved in the strife of arms, the neutrals, take sides spiritually and morally. The whole world is divided and torn into two great hostile camps. The greater part of the Latin world is our enemy. The intellectual bridges which connect nations seem to have been shattered, and across the yawning abyss ugly and agitated words are flying back and forth. The worst civil war is raging in the *Republica litterarum*, in the domains of science and art, which at other times unite all mankind and make of them world-citizens of a *Civitas Dei*.

"But of that civil war of the world let us not speak here. We have met for a labor of peace. The appeal which we teachers of German universities sent out into a world torn by war begins with the words 'We professors at Germany's universities serve science and devote ourselves to a labor of peace.' As soon as your teacher has ascended this platform and has closed the door of this lecture-room to the outer world, we shall and must turn away our thoughts for an hour from that which day and night oppresses our hearts, and we must compel our minds to concentrate on scientific work. The passions of the day must not enter here: we will leave them behind us. Science demands of us this act of self-discipline and of self-control. Whoever does not feel capable of it will not be able to serve science or to enter into any close relation to her; he will remain unsatisfied even in this lecture-hall devoted to her service.

"I should like to speak to you here of the French culture of the past, just as I have always done since I first took upon myself, thirty-five years ago, this task in Bern, on the borderland of the French and German languages. At that time I referred to Goethe, as I do to-day; for he has taught us that, with sympathetic interest for the culture of the Latin peoples, may be combined a deep love for the Teutonic, for our own. For all these years I have spoken to German youth of these Latin subjects with a feeling born of respectful regard for what is foreign to us, and of love for what is our own. That they appreciate what I have done they have kindly proved to me, even in these dreadful days, when friendly notes from writers personally unknown to me have reached me from the western front, expressing grateful remembrance of the hours when they had here studied French culture with me.

"The purely scientific character of these lectures, therefore, will not be changed. I should like, as heretofore, to train your minds to a scientific mode

of thought, and to lead you to a dispassionate historical conception and judgment of things of the past of foreign lands. Scientific work of this kind does not separate, it unites; it teaches to understand and to discern, not to despise. While I am saying this to you, the figure of my teacher, Gaston Paris, appears before me. Those years of study, those fellow-students, arise before my mind, with which are connected indelible memories of distant days of my youth and of recent happy intercourse. You have often heard from me the names of these collaborators and investigators. I have often here expressed to you what our science owes them, for what I myself am indebted to them.

"Beyond the bloody struggle of the present looms the dominating personality of Gaston Paris. Gratefully I salute his spirit from this place. I have often acknowledged the deep decisive influence he has exercised upon me; the best that I can give you has been aroused in me by him. Listen to the words with which he, the man of thirty, reopened his lectures at the Collège de France in December, 1870, in besieged Paris, 'surrounded by the iron ring, which the German armies have closed about us.' After a short reference to the work of the last term and to the students who had followed the call to arms, and some of whom might be in the hostile army of the besiegers, he spoke of the scientific problems which even in these anxious hours, 'when the Fatherland claimed all our thoughts,' still had a right to be considered.

I do not believe that, on the whole, patriotism has anything to do with science. The lecture-room is no political platform. Whoever uses the lecture-room to defend or to attack anything that lies outside of its purely intellectual province diverts it from its true purpose. I advocate unconditionally and without reservation the doctrine that science must adopt as her only aim the search of truth—truth for her own sake, without troubling herself whether this truth may, if put into practise, have good or evil, regrettable or gratifying consequences. Whoever indulges in the slightest concealment, the most trifling change in the presentation of those facts which are objects of his research, or in the deductions which he draws therefrom—though led by patriotic, religious or even moral considerations—is not worthy of a place in the great laboratory to which honesty is a much more indispensable title than skill or cleverness.

If the studies pursued in common are so conceive¹ and are carried on in this spirit in all civilized countries, then they will constitute a great Fatherland, high above all barriers of hostile nationalities, undefiled by war, unmenaced by conquerors, in which minds can find t refuge and union which the Civitas Dei offered them in other days.

"Thus a young French scientist, who was at the same time an ardent patriot, spoke to his hearers on December 8, 1870. I do not know if patriotism in Paris has found similar expression to-day. Time will show. But I wish to remind you to-day of the words of this strong and noble man, who combined in wonderful harmony loyalty to the soil and citizenship of the world—love of his country and love of truth. May his words not have been spoken in vain!

"The German student of Romance subjects finds the fields of his labors to a great extent covered with ruins. The blossoms which had promised fruit have been blighted. The fruit which seemed already garnered is destroyed. New life will surely blossom from these ruins, for nature wills it so, for the salvation of mankind. Wherever the ground is strewn with wreckage we shall again draw furrows and scatter seed, and those who come after us will gather the harvest. And Teutons and Latins will enjoy it in common. Without this faith in the power and the perpetuity of the *Civitas Dei* of science, I should not stand before you to-day as your teacher of Romance philology, and your guide through French literature of the eighteenth century, which domain we expect to explore during this winter term quietly and with steadfast purpose."

PROFESSOR ONNES AND THE LEIDEN LABORATORY OF PHYSICS

The Franklin Institute has made the first awards of its Franklin medal, established last year by a gift from Mr. Samuel Insul, to Mr. Thomas Alva Edison and to Professor Heike Kamerlingh Onnes. Mr. Edison's great contributions to the applications of science are known to us all. It may be of interest to give some statement of the work of Professor Onnes and the Leiden Laboratory, taken from the report of the institute. At the present time it is well to remember the important contributions made to science by the smaller nations. It is certainly a remarkable fact that Holland should have more physicists of high distinction than the United States.

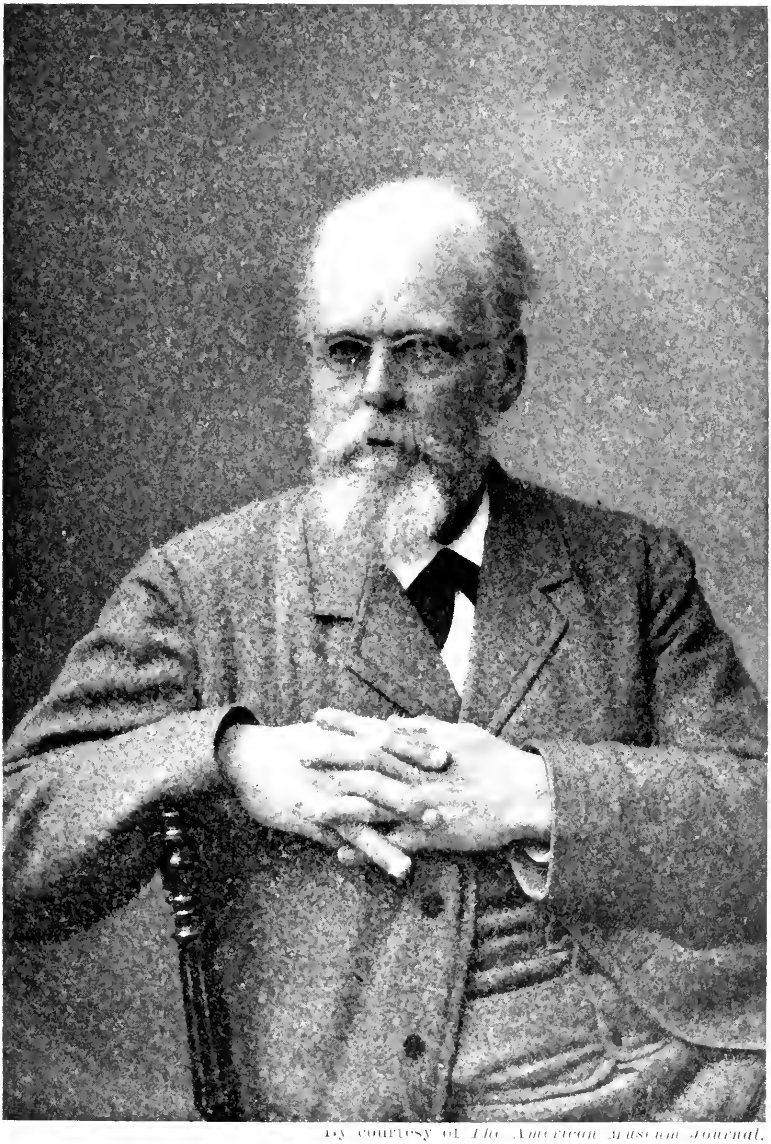
Heike Kamerlingh Onnes was born on September 21, 1853, at Groningen, Holland, where his father was engaged in manufacture. He was educated in the schools of his native town, and there also he began his university studies in 1870. Two years later he removed to Heidelberg, where he spent three semesters, working under the direction of Bunsen and Kirchoff. He then returned to Groningen, and a few years after he became assistant to Professor Bosscha at Delft, where he commenced work upon his thesis for the doctorate. In 1882 he and H. A. Lorentz were appointed professors of physics in the University of Leiden, then a little known and quite unpretentious seat of learning (so far as physical science was concerned), but which, as a result of the collaboration of these two highly-gifted young physicists, has become one of the world's great centers of physical research.

While Lorentz confined his energies mostly to the fields of theoretical and mathematical physics, Onnes directed his energies to the creation of a laboratory for experimental research. In spite of great obstacles, particularly of very inadequate appropriations for equipment and maintenance, the indefatigable director found ways and means of furnishing his laboratory with the special machinery and precision instruments required for the researches of the professors and their students. A very important—in fact, an essential—factor in this development was the establishment by Onnes of a training school for mechanicians, and it was in the shops of this school that many of the special instruments for the laboratory were constructed. At the same time the young men engaged there were trained to assist the director in carrying out the often difficult and intricate operations in his experimental work. On various occasions Professor Onnes was thus enabled to command a force of some thirty assistants, to each of whom a special duty was assigned.

The work of this great laboratory at Leiden is recorded in the *Leiden Communications*, published since 1891, and includes a vast number of most important contributions to physical science. Among them are investigations on magneto-electric effects, as well as a series of most important papers upon magneto-optical phenomena, such as the classical one by Zeeman, describing the discovery of what is now known as the Zeeman-effect. But, while these early investigations were all carried out under Onnes's direction, they were in many cases inspired or suggested by his distinguished colleague, H. A. Lorentz.

The really representative work of the laboratory has been in the field of molecular physics, and particularly in research at low temperature. The great bulk of the *Leiden Communications* is devoted to the records of those remarkable series of researches which were conceived by Onnes himself and carried out under his direction.

The history of these researches began with the creation of the cryogenic laboratory, and it may be divided into several distinct stages or periods. The first of these was occupied with the production of liquid oxygen on a large scale, and with the use of this material in a three-cycle process of obtaining



By courtesy of *The American Museum Journal.*

AUGUST WEISMANN

The distinguished zoologist, late professor in the University of Freiburg, known especially for his contributions to the theory of heredity.

low temperatures, by which Onnes was enabled to maintain and control the temperature ranges from —23° to —90° (methyl chloride), from —105° to —165° (ethylene), and —183° to —217° (oxygen). This goal may be said to have been attained about 1894. The second stage was characterized by the introduction of liquid hydrogen and the production of temperatures below —217°. The abnormal behavior of hydrogen gas when it is allowed to expand under reduced pressures made it impossible to liquefy it at higher temperatures; and the condensation of this gas was first achieved by Dewar, of London, on May 10, 1898. This added a new range of available low temperatures from —253° to —250° in which Dewar made a number of highly remarkable observations, including the solidification of hydrogen. But Onnes very promptly appropriated this new range for his research work, and constructed novel and very efficient apparatus for the production and utilization of the new refrigerant.

The Netherlands government, realizing the importance of the work, now granted considerable appropriations for the extension and equipment of the laboratory, and with its completion a new era of constantly increasing low temperature research began. New methods and instruments for the exact measurement of temperatures below the boiling-point of liquid hydrogen were devised, and the behavior of mixtures of hydrogen and helium was systematically investigated. Finally, the apparently incoercible gas, helium, was reduced to the liquid state. This crowning triumph of low temperature research was achieved on July 10, 1908. This achievement aroused universal interest in the work of Onnes and doubtless prompted the award to him, in 1913, of the Nobel Prize in Physics.

During the past few years Onnes has made some most remarkable discoveries with reference to the electrical resistance of certain metals at temperatures only a few degrees above the absolute zero of temperature. The resistance of metals ordinarily varies approximately with the absolute temperature, but at temperatures only a few degrees above the absolute zero it suddenly becomes so small that it can hardly be measured. For mercury this "critical temperature" is 4.2° absolute; for lead it is 6.1°, and for tin 3.8°. Below these temperatures the resistance is practically *nil*, and Onnes terms this the "supraconductive" state. In this state the metals no longer obey Ohm's law—there is neither a potential drop nor a production of heat.

SCIENTIFIC ITEMS

We record with regret the deaths of Joseph Johnston Hardy, professor of mathematics and astronomy at Lafayette College; of Dr. Samuel Baldwin Ward, since 1884 dean of the Albany Medical College and professor of the theory and practise of medicine, and of James Blaine Miller, of the Coast and Geodetic Survey, a passenger on the *Lusitania*.

The Barnard gold medal awarded every fifth year by Columbia University, on the recommendation of the National Academy of Sciences, "to that person who, within the five years next preceding, made such discovery in physical or astronomical science, or such novel application of science to purposes beneficial to the human race, as may be deemed by the National Academy of Sciences most worthy of the honor," will be given this year to William H. Bragg, D.Sc., F.R.S., Cavendish professor of physics in the University of Leeds, and to his son, W. L. Bragg, of the University of Cambridge, for their researches in molecular physics and in the particular field of radio-activity. The previous awards of the Barnard medal have been made as follows: 1895—Lord Rayleigh and Professor William Ramsay; 1900—Professor Wilhelm Conrad von Röntgen; 1905—Professor Henri Becquerel; 1910—Professor Ernest Rutherford.

THE POPULAR SCIENCE MONTHLY

AUGUST, 1915

THE CONSTITUTION OF MATTER AND THE EVOLUTION OF THE ELEMENTS[1]

By Professor Sir ERNEST RUTHERFORD, F.R.S.

UNIVERSITY OF MANCHESTER

SPECULATIONS as to the constitution of matter have occupied an important place in the development of scientific knowledge. The idea that all matter was composed of minute particles called atoms was put forward long ago by the Greek philosophers, and was advanced again with varying degrees of confidence by philosophic men at the dawn of the scientific age. For example, Newton suggested that matter was composed of atoms which were likened to "hard massy balls," while Robert Boyle regarded a gas to consist of atoms which were in brisk motion. The first definite formulation of the atomic theory as a scientific hypothesis was given by Dalton of Manchester in 1803 in order to explain the combination of atoms in multiple proportion. The necessity of distinguishing between the chemical atom and the chemical molecule was soon recognized, while the famous hypothesis of Avogadro that equal volumes of all gases at the same temperature and pressure contain equal numbers of molecules still further extended the usefulness of the theory. The whole superstructure of modern chemistry has been largely reared on the foundations of the atomic theory. The labors of the chemist have revealed to us the presence of more than eighty distinct types of elements, each of which has a characteristic atomic weight, and in most cases sufficiently distinct physical and chemical properties to allow of its separation from any other element by the application of suitable methods.

It has been generally assumed that all the atoms of one element are identical in shape and weight, and until a few years ago were supposed to be permanent and indestructible. The close study of the variation of chemical properties of the elements with atomic weight led Frankland and Mendelief to put forward the famous "periodic law," in which it was shown that there was a periodic variation in the chemical proper-

[1] First course of lectures on the William Ellery Hale Foundation, National Academy of Sciences, delivered at the Washington Meeting, April, 1914.

ties of elements when arranged in order of increasing atomic weight. This empirical generalization has exercised a wide influence on the development of chemistry, and the periodic law has been considered by many to indicate that all the atoms are composed of some elementary substance or protyle. It is only within the last few years that our knowledge of atoms has reached a stage to offer a reasonable explanation of this remarkable periodicity.

Time does not allow me to more than refer in passing to the important contributions of Le Bel and van' t Hoff to the structure of complex molecules, and the arrangements of the atoms in space, which has exercised such a wide and important influence on the development of organic chemistry.

While the chemist was busy disentangling the elements, determining their relative atomic weights and studying their possible combinations, the physicist had not been idle. The idea that a gas consisted of a large number of molecules in swift but irregular movement had been tentatively advanced at various times to explain some of the properties of gases. These conceptions were independently revived and developed in great detail by the genius of Clausius and Clerk Maxwell about the middle of the last century. On their theory, now known as the kinetic or dynamical theory of gases, the molecules of a gas are supposed to be in continuous agitation, colliding with each other and with the walls of the containing vessel. Their velocity of agitation is supposed to increase with temperature, and the pressure is due to the impact of the molecules of the gas on the walls of the enclosure. This theory was found to explain in a simple and obvious way the fundamental properties of gases, and has proved of great importance in molecular theory. The idea that atoms must be in brisk and turbulent motion is strongly supported by the well-known property of the interdiffusion of gases and also of liquids, and in recent years has received practically a direct and concrete proof from the study of a very interesting phenomenon included under the name "Brownian Motion." The English botanist, Brown, in 1827 discovered that small vegetable spores immersed in a liquid appeared to be in continuous motion when viewed with a high power microscope. This motion of small particles in liquids was at first supposed to be a result of temperature disturbances, but at the close of the last century the Brownian movement was shown to be a fundamental property of small particles in liquids. The whole question has been investigated in recent years with great ability and skill by Perrin. He examined in detail the state of equilibrium and of motion of minute particles in suspension in liquids. The excursions due to the Brownian movements depend mainly on the size of the particles, although influenced to some extent by the nature of the liquid. Small spheres of the size required can be produced by a variety of methods. One of the simplest used by Perrin is to allow a solution

of pure water to pour slowly out of a funnel under an alcoholic solution of gamboge or mastic. An emulsion is formed where the layers meet which consists of a great number of minute spheres. When these particles are viewed in a strong light with a high power microscope, they all exhibit the characteristic Brownian movement, *i. e.*, the particles dart to and fro in irregular and tumultuous fashion, and never appear to be at rest for more than a moment. The motions of these small particles under a microscope irresistibly convey the impression that they are hurled to and fro by the action of mysterious forces resident in the solution. Such a result is to be anticipated if the molecules of the liquid are themselves in rapid though invisible tumultuous motion of the kind outlined on the kinetic theory. The particle is very large compared with the molecule, and it is bombarded on all sides by great numbers of molecules. Occasionally the pressure due to the bombardment is for a moment greater on one side of the particle than on the other, and the particle is urged forward, until a new distribution of impacts hurls it in another direction. In fact, the movement of these particles has been found to conform exactly with that predicted by the molecular theory.

It would take too long to discuss the remarkable conclusions that Perrin has reached from a study of the distribution and motion of small particles. The particle which may be an agglomeration of many millions of molecules, behaves in many respects like the much smaller molecule. A great number of particles in a liquid do not distribute themselves uniformly under gravity, but the numbers decrease with height according to the same law as the gases in our atmosphere.

On the kinetic theory, we thus have strong evidence for believing that the atoms of matter, whether in the solid, liquid or gaseous form, are in continuous agitation and irregular motion. The velocity of agitation decreases with lowering of temperature, and at the lowest attainable temperature the motion has either ceased or become very small.

It is well known that under suitable conditions, the same type of matter can exist in three distinct forms, solid, liquid and gas. If we take the ordinary air of the room, it can be turned into a clear liquid under certain conditions of temperature and pressure, and this liquid can be frozen solid by still further lowering of the temperature. The most refractory gas of all, helium, has only recently been shown to conform with the behavior of all other gases, and to pass into a liquid at a temperature only a few degrees removed from absolute zero. The remarkable changes in appearance and physical qualities of an element in passing from one state to another is a matter of common knowledge—but it is not for that reason very easy of explanation. These changes are believed to be connected with the average distance which separates one atom or molecule from the other and their rapidity of motion. In the gas or vapor form, the molecules are, on an average, so far apart

that their mutual attractions are relatively unimportant. With lowering of temperature, the distance and rapidity of motion of the molecules diminish until under certain conditions, the attraction of the molecules for one another predominates, resulting in a much closer packing, and the appearance of the liquid form. The molecules, however, still retain a certain freedom of motion, but this is diminished with lowering of the temperature until at a certain stage the molecules form a tighter grouping, corresponding to the solid state where the freedom of motion of the individual molecules is much restricted. In order to account for the resistance of solids to compression or extension, it has been supposed that the force between molecules is attractive at large distances but repulsive at small distances. While we are able to offer a general explanation of the passage of an element from one state to another, a complete explanation of such phenomena will only be possible when we know the detailed structure of the atoms and the nature and magnitude of the forces between them.

While the kinetic theory of gases has proved very successful in explaining the fundamental properties of gases, its strength, and at the same time its weakness, lies in the fact that in most cases it is unnecessary for the explanation to know anything of the structure of the atom or molecule, or of the forces between them. In some investigations, in order to explain some of the more recondite properties of gases, assumptions have been made of definite laws of force between the molecules, but no very definite or certain results have so far been achieved in this direction. It should, however, be pointed out that the kinetic theory afforded us for the first time with a satisfactory method of estimating approximately the dimensions of molecules and the actual number in a given weight of matter. As the recent development of science has provided us with more certain methods of estimation of these important quantities, we shall not enter further into the question at present.

Crystals

There is another very striking form that matter sometimes assumes, which has always attracted much attention and which has recently emerged into much prominence. It is well known that the majority of substances under suitable conditions form crystals of definite geometrical form, which is characteristic of the particular atoms or groups of atoms. The great variety of crystal forms that are known have all been classified as belonging to one or more of the 230 forms of point symmetry which are theoretically possible. While considerations of symmetry are a sufficient guide to the classification of crystals, they offer no explanation of the definite architecture of the crystal nor of the nature of the forces that cause the atoms or molecules to arrange themselves in such definite geometric patterns. We are inevitably led

to the conclusion that the atoms of the crystal are arranged according to a definite system, which is characteristic of the particular crystalline form, and the unit of structure is repeated indefinitely with continued growth of the crystal. In fact, if we had no other evidence, the crystalline form of matter would itself point to the necessity of an atomic structure of matter. While many attempts have been made to explain the grouping of the atoms in a crystal, there has been on the whole little success with the exception, possibly, of Pope and Barlow's theory that the atoms take up the positions of closest packing, the dimensions assigned to the atom depending on a quantity connected with its chemical valency. It is only within the last year that a new and powerful method of attack of this problem has been developed, largely through the experiments of Professor Bragg and his son, W. L. Bragg. On account of the definite ordering of the atoms in a crystal, it acts like an almost perfect optical grating, only in three dimensions, where the grating space is exceedingly small—in most cases about one hundred millionth of a centimeter. Laue showed that when Röntgen rays passed through a crystal, definite interference patterns were observed. This result was of great importance, as it showed that Röntgen rays must consist of very short transverse waves akin to those of light. Bragg showed that the reflection, or rather diffraction, of Röntgen rays incident on the face of a crystal, afforded a very simple method of determining the wave length of the bright lines generally present in an X-ray spectrum. By a study of the position and intensity of the spectra

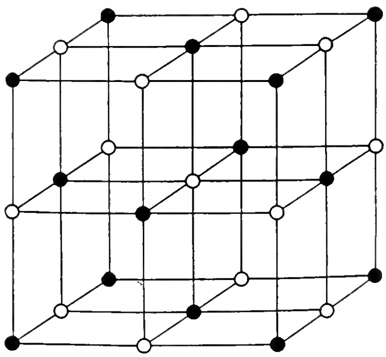


FIG. 1. ARRANGEMENT OF ATOMS IN A ROCK SALT (NaCl) CRYSTAL, WHITE CIRCLES REPRESENT SODIUM ATOMS, BLACK CHLORINE.

in different orders thrown by the crystal, it was possible to examine in detail the structure of the crystal, and to deduce the grating space, *i. e.*, the distance between successive planes of atoms. The subject is so large and the discovery of this method so recent, that so far only a few of the typical crystals have been examined, but in these cases we are able to obtain most positive evidence of the grouping of the atoms in the crystal. The results indicate that the atom and not the mole-

cule is the unit of the crystal structure. Consider the structure of the simple cubic crystal of rock salt (sodium chloride). The structure of the crystal deduced by Bragg is shown in Fig. 1. The sodium atoms are marked by black spheres, the chlorine atoms by white spheres. The simplicity of the crystal architecture is obvious, for all the atoms are equi-distant. The structure of the diamond is more complicated but it is one of great interest, for all the atoms in these cases are of one kind, carbon. The structure found by Bragg is seen in Fig. 2*A*.

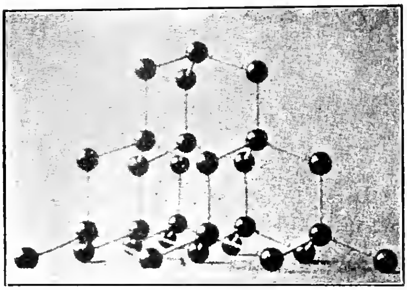


Fig. 2a. Arrangement of Carbon Atoms in a Diamond.

The atoms are all equi-distant, but the general arrangement differs markedly from that of rock salt. It is seen that each carbon atom is linked with four neighbors in a perfectly symmetrical way, while the linking of six carbon atoms in a ring is also obvious from the figure. The distance between the planes containing atoms is seen to alternate in the ratio 1 : 3. This variation of the grating space is brought out clearly

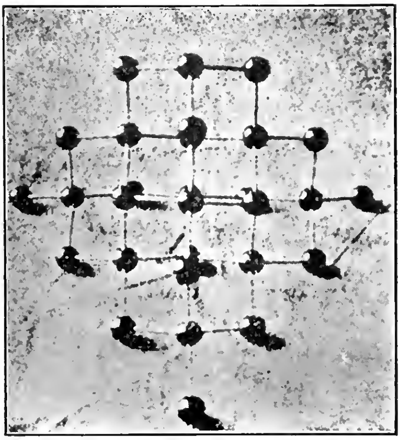


Fig. 2b. Cubical Arrangement of Carbon Atoms in a Diamond.

from the study of the spectra, and is an essential feature of the structure of the diamond. The cubical arrangement is shown by turning the model so that the lines joining the atoms are vertical and horizontal (see Fig. 2*B*).

Now that we have a method of determining the arrangement and distances apart of the atoms in a crystal, the next step will be to examine the intensity and type of forces which are brought into play to keep the atoms in equilibrium and relatively fixed in their places. It is to be expected that the atoms are able to move to and fro about their position of equilibrium, and this is indicated by the effect of lowering the temperature of the crystal; for the intensity of the diffraction spectra increases as the amplitude of motion of the atom diminishes. The sharpness of the diffraction spectra suggests that the atoms are not only arranged at definite distances from one another but that each atom is orientated in a definite position with regard to its neighbor.

While varieties of crystals are known of all degrees of hardness, the work of Lehmann has brought to light the unexpected existence of crystalline arrangement in some liquids. These liquid crystals are best shown in certain complex organic substances at a temperature slightly above their melting point, and they are only observable in the liquid by the patterns and colors developed when polarized light passes through them. These crystals are mobile like a drop of oil in a solution and can be squeezed into a variety of patterns. Such results would indicate that the molecules of the liquid have a tendency to arrange themselves in ordered patterns, although it is difficult to understand how the freedom of relative motion that is supposed to characterize a liquid can contemporaneously exist with an ordered arrangement of some of the constituent molecules.

Light Spectra

We will now direct our attention to another type of phenomenon which ultimately promises to throw much light on the detailed structure of the atom. When the light from an incandescent vapor or gas is passed through a prism or reflected from a grating, it is resolved and gives a characteristic spectrum consisting of a number of bright lines. By suitable methods, the wave-length of these radiations can be determined with great accuracy. Each of these lines represents a definite and characteristic mode of vibration of the atom, and from the exceeding complexity of the spectra of many of the heavy elements, we are forced to conclude that an atom can vibrate in a great variety of ways. When the meaning of the dark lines in the solar spectrum was correctly interpreted, we were enabled at one stride to extend our methods of observation to the sun and the furthest fixed stars. It was soon recognized that atoms of the same element always vibrated the same way under all conditions. It was found, for example, that hydrogen atoms in the earth vibrated in exactly the same way as the same atoms in a distant star. The important bearing of this result on the structure of atoms was pointed out by Clerk Maxwell in his well-known address on "Atoms

and Molecules" before the British Association at Bradford in 1873, from which it is interesting to quote the following.

In the heavens we discover by their light, and by their light alone, stars so distant from each other that no material thing can ever have passed from one to another; and yet this light, which is to us, the sole evidence of the existence of these distant worlds, tells us also that each of them is built up of molecules of the same kinds as those which we find on earth. A molecule of hydrogen, for example, whether in Sirius or in Arcturus, executes its vibrations in precisely the same time.

Each molecule[1] therefore throughout the universe bears impressed upon it the stamp of a metric system as distinctly as does the metre of the Archives at Paris, or the double royal cubit of the temple of Karnac.

No theory of evolution can be formed to account for the similarity of molecules, for evolution necessarily implies continuous change, and the molecule is incapable of growth or decay, of generation or destruction.

None of the processes of nature, since the time when nature began, have produced the slightest difference in the properties of any molecule. We are therefore unable to ascribe either the existence of the molecules or the identity of their properties to any of the causes which we call natural.

On the other hand, the exact equality of each molecule to all others of the same kind gives it, as Sir John Herschel has well said, the essential character of a manufactured article, and precludes the idea of its being eternal and self-existent.

While there is no doubt that an atom of an element in the earth or in a star vibrates in identical fashion under the same physical conditions, it is now known that the frequency of vibration of an element is not the exact constant that was at first supposed. It is altered to a slight extent by motion of the source, by change of pressure, and by the application of magnetic and electric fields. The apparent change of frequency of vibration with the motion of the source relative to the observer has proved an invaluable method for studying the motion of stars in the line of sight, while the displacement of the lines of hydrogen in the sun has in the hands of Professor Hale and his assistants proved of great power in throwing light on some of the physical conditions that exist in that distant body. It has been found that there is order and system in the great complex of modes of vibration of an atom, and that many of the lines can be arranged in definite series whose rates of vibration are connected by simple and definite laws. It is only within the last year or two that we have been able to form some idea of the origin of these spectra and the meaning of a spectral series. The fact that the lightest and presumably the simplest atom known, viz., hydrogen, gives a very complicated light spectrum was at first, and quite naturally, believed to indicate that the hydrogen atom must be a very complex structure. We shall see later, however, that the hydrogen atom is believed to have an exceedingly simple structure, and that the complexity of the spectrum is to be ascribed rather to a complexity in the laws of radiation.

[1] Maxwell used the term "molecule" where we now use the term "atom."

We have seen that the study of the spectrum led Maxwell to conclude not only that the atoms were identical in weight and form but that they were the only permanent and indestructible units in this changing world. The apparent identity of the spectrum under all conditions certainly strongly supported such a view at that time. It was believed that if some of the atoms were changing, it would be shown by a *gradual* alteration of their modes of vibration, *i. e.*, of the spectrum. It was left to the beginning of this century to show the fallacy in this deduction, and to bring undoubted evidence that some elements at least are undergoing spontaneous transformation with the appearance of new types of matter giving a new and characteristic spectrum. This question will be discussed later in some detail.

Electrons

Before, however, considering the bearing of radioactive phenomena on the structure of the atom, I must refer to a discovery which has exercised a most profound influence on the development of physics in general and on our ideas of the structure of atoms. Sir William Crookes long ago found that when an electric discharge was passed through a vacuum tube at very low pressures, a peculiar type of radiation appeared, known as the "cathode rays." This radiation appeared to be projected from the cathode in straight lines, and, unlike light, was deflected by a magnet. These rays excited strong phosphorescence in many substances in which they fell, and also produced marked heating effects. Crookes concluded that the cathode rays consisted of a stream of negatively charged particles moving at high speed. The general properties of this radiation appeared so remarkable that Crookes concluded that the material constituting the cathode stream corresponded to a "new or fourth state of matter." After a controversy extending over twenty years, the true nature of these rays was finally independently shown in 1897 by the experiments of Weichert and Sir J. J. Thomson. They proved, as Crookes had surmised, that the rays consisted of a stream of negatively charged particles travelling with enormous velocities from 10,000 to 100,000 miles a second, depending on the potential applied to the vacuum tube. In addition, it was found that the mass of the particle was exceedingly small, about 1/1800 of the mass of the hydrogen atom—the lightest atom known to science. These results were soon confirmed and widely extended. These corpuscles, or electrons, as they are now termed, were found to be liberated from matter not only in an electric discharge but by a variety of other agencies; for example, from a metal on which ultra-violet light falls, and also in enormous numbers from an incandescent body. Radium and other radioactive substances were found to emit them spontaneously at much greater speeds than those observed in a vacuum tube. It thus appeared that the electrons must be a constituent of the atoms of mat-

ter and could be released from the atom by a variety of agencies. This idea was much widened and strengthened by the investigations of Zeeman and Lorentz, who showed that the radiation of light must be mainly ascribed to the movements of electrons of the same small mass within the atom.

It does not fall within the scope of my address to outline the very important consequences that followed in many directions from this fundamental discovery of the independent existence of the electron and its connection with matter. It was found by Kaufmann that the mass of the electron was not a constant but increased with its speed, and from this result it was deduced that the electron was an atom of disembodied or condensed electricity occupying an exceedingly small volume, whose mass was entirely electrical in origin.

Unit of Electricity

I should mention here one important consequence that has followed from these discoveries. From the laws which control the passage of electricity in conducting solutions, Faraday recognized that there must be a close connection between the atom of matter and its electrical charge. Maxwell and Helmholtz suggested that the results were simply explained by supposing that electricity was atomic in nature. This conclusion is now definitely established, and the positive charge carried by the hydrogen atoms in the electrolysis of water is believed to be the fundamental unit of electrical charge. This charge is equal to and opposite to the charge carried by the electron. Any charge of electricity, however small or large, must be expressed by an integral multiple of this fundamental unit of electricity. The actual value of this unit charge has been measured by a great variety of methods and with concordant results. One of the most detailed and accurate investigations of this important constant has been made by Professor Millikan, of the University of Chicago.

Objections to the Atomic Theory

We have so far implicitly assumed that the great majority of scientific men now regard the atomic theory not only as a working hypothesis of great value but as affording a correct description of one stage of the sub-division of matter. While this is undoubtedly the case to-day, it is of interest to recall that less than twenty years ago there was a revolt by a limited number of scientific men against the domination of the atomic theory in chemistry. The followers of this school considered that the atomic theory should be regarded as a hypothesis, which was of necessity unverifiable by direct experiment and should, therefore, not be employed as a basis of explanation of chemistry. This point of view was much strengthened by the recognition of the power of thermodynamics in affording a quantitative explanation of the

changes of energy in chemical reactions without the assumption of any definite theory of the constitution of matter. This tendency advanced so far that text-books of chemistry were written in which the word atom or molecule was taboo, and chemistry was based instead on the law of combination in multiple proportion. At that time, it did undoubtedly appear that there was little, if any, hope of finding a concrete proof of the validity of the atomic hypothesis, or of detecting by its effects a single atom of matter or a single electron, for it was known that the smallest fragment of matter visible under a high power microscope must still contain many millions, or even billions, of atoms.

The march of science has, however, been so rapid in this direction that we have been able in recent years to show in a definite and concrete way the independent existence of atoms and also of electrons in rapid motion.

Counting Atoms and Electrons

We shall first of all consider the method devised by Rutherford and Geiger for detecting and recording the effects of single alpha particles from radium. At this stage, it is unnecessary to enter into details of the nature of the transformations occurring in radioactive matter. It suffices to say here that the atoms of a radioactive substance are unstable and occasionally break up with explosive violence. In many cases, the explosion is accompanied by the ejection of a charged body, called the alpha particle, with a velocity of about 10,000 miles a second. These alpha particles are known from other investigations to consist of charged atoms of the rare gas helium. The presence of these rays is simply shown by the marked phosphorescence they set up in certain substances. I have here a fine glass tube which was filled about a week ago in Manchester with purified emanation released from about one fifth of a gram of pure radium. In the interval of its journey across the Atlantic, the activity of the emanation has decayed to about one quarter of its original value. The glass walls of the tube are made so thin—about 1/100 millimeter—that the alpha rays are able to escape freely into the surrounding air. They produce a small phosphorescence in the walls of the glass tube which is just visible in the darkened room. On bringing near, however, a screen covered with zinc sulphide, a brilliant phosphorescence is observed which increases in intensity as we approach the tube. Similar effects are seen to be produced in this crystal of willemite, while the crystal of kunzite is seen to be translucent and emit a ruddy light. This phosphorescence of zinc sulphide and willemite is due mainly to the alpha rays, and from the present emanation tube about 5,000,000,000 of these particles are projected each second.

In their passage through air or other gas, the alpha particles produce from the neutral molecules a large number of negatively charged

particles called ions. The ionization due to the alpha particles can be readily measured by electrical methods, and it can be shown that the effect to be expected from a single alpha particle is much too small to detect except by very refined methods. In order to overcome this difficulty, Rutherford and Geiger employed a method of magnifying automatically several thousand times the electric effect due to an alpha

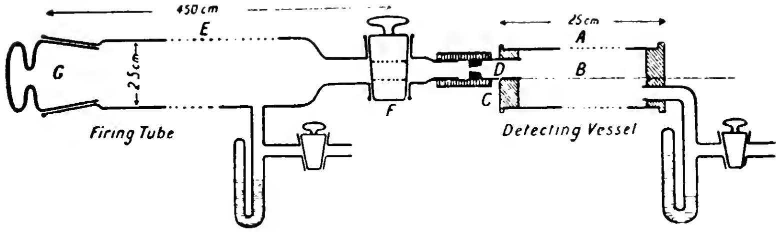


FIG. 3. APPARATUS FOR COUNTING ALPHA PARTICLES.

particle. The general arrangement of the original apparatus is seen in Fig. 3.

A few of the alpha rays from a radioactive substance passed along an exhausted tube E through an opening D covered with thin mica into the detecting tube AB. The latter contained a central insulated electrode B connected with an electrometer, and the pressure of the gas inside was adjusted to a few centimeters of mercury. The tube B was connected with the negative pole of a battery of about 1,500 volts, the other pole being earthen. The potential was adjusted so that a spark was on the point of passing between A and B. Under such conditions, the ionization due to an alpha particle passing along the detecting vessel is magnified several thousand times by collision of the negative and positive ions with the neutral molecules.

The entrance of an alpha particle into the detecting vessel is then signified by a sudden *ballistic* throw of the electrometer needle, and the number of particles entering the vessel in a given time can be counted by observing the throws. The amount of active matter and its distance from the opening were adjusted so that three to five alpha particles entered the opening per minute. The following table illustrates the results obtained:

	Number of Throws	Magnitude of Successive Throws, Scale Divisions
1st minute..............	4	11, 12, 10, 11
2d minute..............	3	10, 11, 8
3d minute..............	5	10, 9, 13, 8, 12
4th minute..............	4	18*, 8, 12
5th minute..............	3	10, 6, 10
6th minute..............	4	9, 10, 12, 11
7th minute..............	2	10, 11
8th minute..............	3	11, 13, 8
9th minute..............	4	8, 20
10th minute..............	3	8, 12, 14, 6
Average per minute, 3.5.	Average throw, 10 divisions.	

It will be seen that the number of throws varies from minute to minute. This is to be expected since the chance of an alpha particle entering the opening is governed by the ordinary laws of probability. It will be seen that two throws, marked by asterisks, are much larger than the others. These were due to the passage of two alpha particles through the opening within a short interval. This was readily seen from the motion of the spot of light reflected from the electrometer needle. As the needle was moving slowly near the end of its swing caused by one alpha particle, a second impulse due to the entrance of another was communicated to it.

By this method, the number of alpha particles expelled from one gram of radium per second was determined. Of course only a minute fraction of the alpha particles was actually counted, but the total number was deduced on the assumption, verified by experiment, that the alpha particles on an average were expelled equally in all directions. In this way, one gram of radium in equilibrium was found to expel the enormous number of 1.36×10^{11} alpha particles each second.

Another interesting result followed from these experiments. It has long been known that the alpha particles produce a marked phosphorescence in crystalline zinc sulphide. When examined by a lens, the light is found not to be uniform but exhibits a very beautiful scintillating effect. By counting the number of scintillations due to the alpha particles, it was found that each scintillation was produced by the impact of a single alpha particle. It is thus seen that two distinct methods, one electrical and the other optical, are available for detecting and counting single alpha particles, *i. e.*, single atoms of matter. This is only possible because the atoms are in swift motion and expend their great energy of motion in ionizing the gas or in producing luminosity in zinc sulphide.

Still another simple method was devised later. Kinoshita first showed that a single alpha particle produced a detectable effect on a photographic plate which was observable under a microscope. A number of experiments have been made by Reinganum, Makower, and Kinoshita to examine the effect of single alpha particles on a photographic plate. If a fine needle point coated with a trace of radioactive matter rests on the surface of the film, the plate on development shows a number of distinct trails radiating from the active point. Each of these trails results from the action of a single alpha particle. A beautiful photograph of this kind (magnification about 300) obtained by Kinoshita is shown in Fig. 4. It appears that each alpha particle makes a certain number of the grains, through which it passes, capable of development.

The use of an ordinary electrometer is not very suitable for counting alpha particles by the electric method, since the time of swing of the electrometer needle is fairly long, and accurate counting can be made

when only a few alpha particles enter the detecting vessel per minute. This difficulty can be got over by the use of a string electrometer in

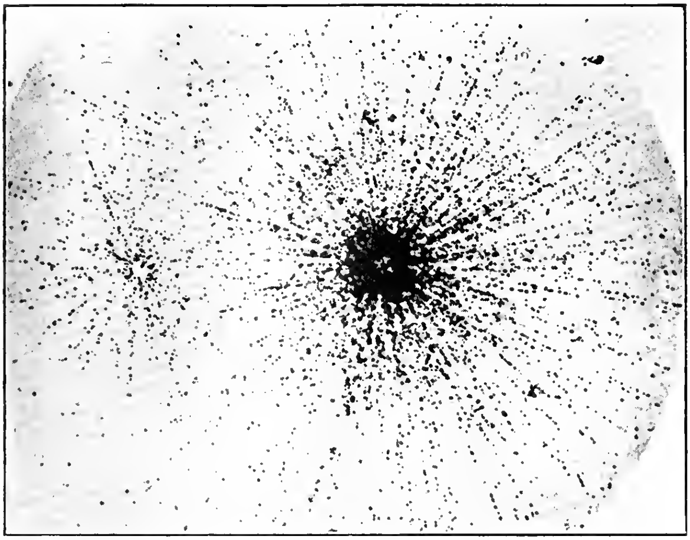


Fig. 4. Photographic Effect due to Alpha Particles from a Central Point.

which the moving system consists of a fine silvered quartz fiber suspended between two charged parallel plates and viewed with a high-power microscope. The entrance of an alpha particle is shown by a sudden movement of the fiber, and if the current is allowed to leak away through a suitable resistance, the fiber returns to the position of rest in a small fraction of a second. The movement of the fiber can be re-

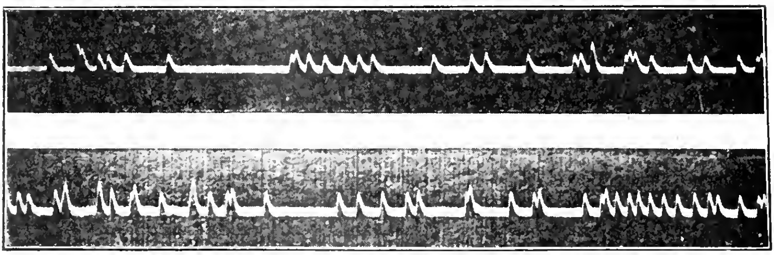


Fig. 5. Photographic Record on String Electrometer of Entrance of Alpha Particles into the Detecting Vessel.

corded photographically on a moving film, and it is possible in this way to count accurately the number of particles, even if several thousand enter the detecting vessel per minute.

Examples of such photographic records, obtained by Rutherford and Geiger, are shown in Fig. 5. The vertical movements of the fiber from the horizontal line are due to the entrance of alpha particles, and it is seen how clearly the detailed movements of the fiber are registered. In some cases, one alpha particle follows another so rapidly that the

fiber has not time to come to rest in between, and this is shown by the saw-like appearance of some of the peaks in the photograph. It will be noticed also that while the heights of most of the deflections are nearly the same, in a few cases the deflections are nearly twice as great as the normal. This is due to the nearly simultaneous entrance of two alpha particles into the vessel. Although the photographic film moved at a constant rate, it is seen that the throws due to the alpha particles are distributed very irregularly along it. A close examination of such records shows that variations of this kind are in accord with the ordinary laws of probability.

During this year, Dr. Geiger has found a still more sensitive detector for counting alpha particles. The arrangement, which is very simple, is shown in Fig. 6. A fine sharply pointed needle ends about

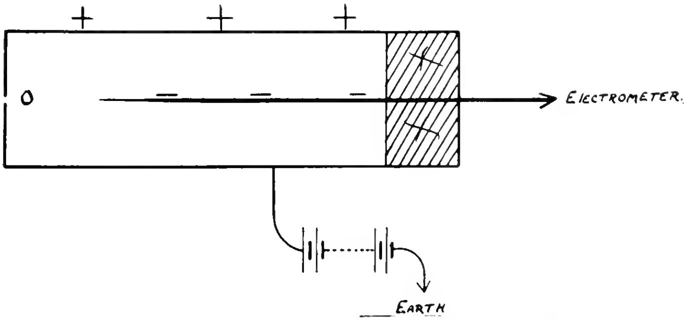


FIG. 6. GEIGER'S DETECTOR OF INDIVIDUAL ALPHA AND BETA PARTICLES.

one centimeter from the opening *O*, where the alpha particles enter. If the outer brass tube be charged positively to about 1,000 volts, and the needle connected with a string electrometer, it is found that the entrance of an alpha particle produces a very great deflection of the fiber. So sensitive is this method, that Geiger has found that individual beta particles can easily be detected and counted by its aid. This is very remarkable when it is remembered that the ionization effect

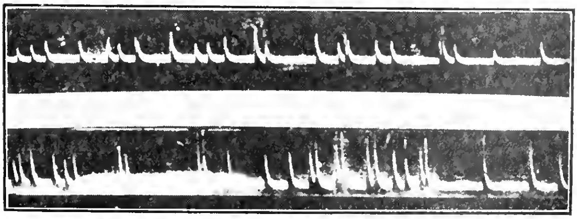


FIG. 7. RECORD WITH STRING ELECTROMETER, UPPER RECORD FOR BETA PARTICLES. LOWER FOR ALPHA PARTICLES.

due to a beta particle is on the average not more than 1/100 of that due to an alpha particle.

A photographic record of the entrance of beta particles into the detecting vessel is shown in Fig. 7. The upper record is for beta par-

ticles and the lower for alpha particles. I am indebted to Dr. Geiger for this photograph. It is seen that the effect of a beta particle is just as marked and as definite as for an alpha particle with the old form of detector. We are thus in a position not only to count single atoms of matter but also to detect the presence of a single electron in swift motion, although the mass of the latter is exceedingly small compared with that of the lightest atom.

I would now very briefly direct your attention to some results, which to my mind not only completely prove the hypothesis of the atomic structure of matter but allow us at once to calculate the number of atoms in a given weight of matter with the minimum amount of assumption. We have seen that by direct counting it has been found that 1.36×10^{11} alpha particles are expelled per second from one gram of radium in equilibrium with its rapidly changing products. Now it has been definitely shown, by methods I need not discuss here, that each alpha particle consists of a helium atom carrying two unit positive charges. Since the alpha particle, when it has lost its charge, becomes a neutral helium atom, we should expect to find that helium would be produced by radium at a definite rate. This is found to be the case, and it is not difficult to determine by actual measurement the volume of helium formed by a known quantity of radium in a given time. It has been found that one gram of radium in equilibrium produces each year 156 cubic millimeters of helium at standard pressure and temperature. Now the number of alpha particles expelled per year per gram is 4.29×10^{18}, giving rise to 156 cubic millimeters of helium; each of these alpha particles is an atom of helium, and consequently the number of atoms of helium in one cubic centimeter of that gas at normal pressure and temperature is 2.75×10^{19}.

It appears to me that no more direct and convincing proof could be obtained of the atomic structure of matter or of the number of atoms forming a given weight or volume of helium; for the number of separate constituents are counted and the volume of the resulting gas is measured. The value so obtained is in good accord with measurements based on entirely different data of various kinds.

It is somewhat remarkable that while the study of radioactive phenomena has clearly indicated that the atom is not always permanent and indestructible, it has at the same time supplied the most convincing proof of the actual reality of atoms, and has provided some of the most direct methods of determining the values of atomic magnitudes.

Tracks of Swift Atoms and Electrons

We have seen how it is possible to detect single alpha and beta particles and to count their number. We will next consider a most remarkable experimental method not only for detecting such particles but of following in detail the effects produced by them in their passage

through a gas. C. T. R. Wilson showed many years ago that the positively and negatively charged ions produced in a gas by the passage of alpha and beta and X rays possessed a remarkable property. When air, for example, saturated with water vapor is suddenly expanded, the air is rapidly cooled and the water tends to deposit on any nuclei present. C. T. R. Wilson showed that in dust-free air, the ions produced by external radiations become nuclei for the condensation of water upon them when the cooling by expansion was sufficiently great. Under such conditions, each ion becomes the center of a visible globule of water, and the number of drops formed is equal to the number of ions present.

C. T. R. Wilson later perfected this method to show the trail of a single alpha or beta particle in passing through the gas; for each of the

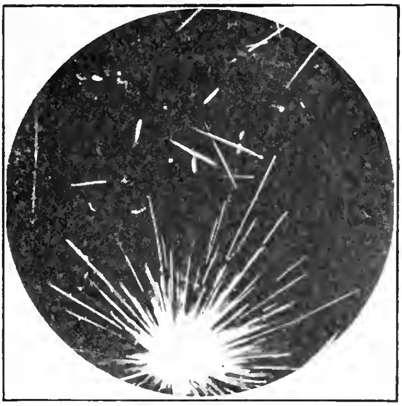


FIG. 8. TRACKS OF ALPHA PARTICLES FROM CENTRAL POINTS (C. T. R. WILSON'S METHOD).

ions produced by the flying particle becomes a visible drop of water by the sudden expansion. By suitable arrangements, the trails of the individual particle can be photographed, and the pictures obtained show with remarkable fidelity and detail the ionizing effects produced in the passage of alpha and beta particles or X rays through gases.

Fig. 8 shows the tracks of the alpha particles shot out from a small fragment of radium. The number of ions produced per centimeter in the gas by the alpha particle is so great that the trail of drops shows as a continuous line. The alpha particles are seen to radiate in straight lines from the active point, and have a definite range in air—a characteristic property discovered by Bragg many years ago. The next photograph (Fig. 9) shows a magnified image of these trails. It is seen that the tracks are generally quite straight, but in a few cases there is a sudden bend near the end. The significance and causes of these sudden deviations in the rectilinear paths of the alpha particles will be discussed later.

A radioactive substance like radium emits not only alpha particles but beta particles which are electrons in very swift motion. These beta particles are generally far more penetrating than the alpha rays, but produce a much smaller number of ions per centimeter of their path

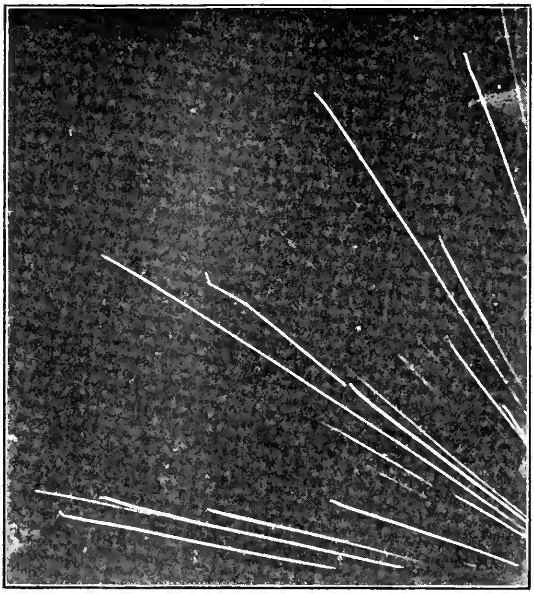


FIG. 9. MAGNIFIED TRACK OF ALPHA PARTICLES (WILSON).

through a gas. In Fig. 10 is seen the track of a swift beta particle crossing the expansion chamber. It will be observed that the path is not straight but tortuous, due to the marked scattering of the particle by collisions with the atoms of matter in its path. Although the trail

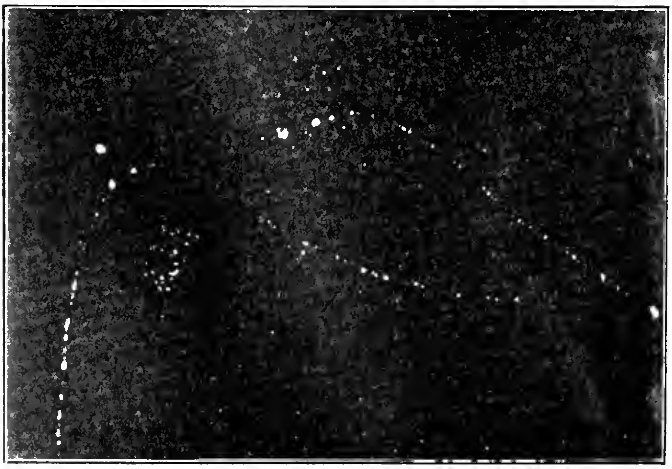


FIG. 10. TRACKS OF BETA PARTICLES.

is clearly defined, the density corresponding to the number of drops per centimeter is much smaller than for the alpha particle. In fact by magnifying still further small portions of the track, the individual ions, or rather the drop formed round each ion produced by the beta particle, are clearly visible. In this way, it is obviously possible to count directly the number of ions produced in any length of the path.

These beautiful photographs thus not only bring out clearly that alpha and beta particles are definite entities but show with great perfection the actual path of the particles in traversing matter. The next photograph (Fig. 11) shows the effect of passing a pencil of

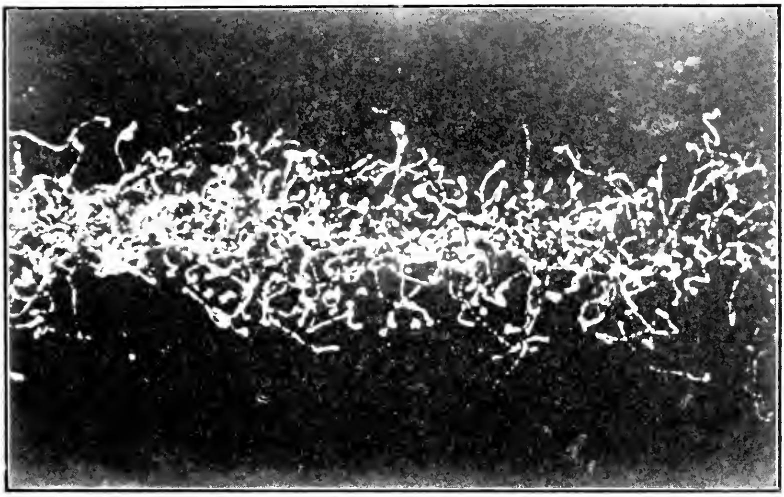


FIG. 11. BETA PARTICLES PRODUCED BY PASSAGE OF X-RAYS THROUGH AIR (WILSON).

Röntgen rays through the expansion chamber. It is believed that these rays do not ionize the gas directly but indirectly through the slow-speed electrons which are liberated by some of the atoms acted on by the radiation. These electrons are not nearly so swift as some of those emitted by radium, for they are only able to transverse a few millimeters of air before being stopped. The photograph brings out clearly these effects, and shows the tortuous path of a beta particle resulting from collisions with the atoms. Such scattering effects become more marked the slower the velocity of ejection of the beta particle.

TRANSFORMATION OF MATTER

While the discovery of the independent existence of the electron as a constituent of the structure of atoms gave a great impetus to the study of atomic structure, it was soon found that the removal or addition of an electron from an atom did not appear to cause a permanent transformation of the atom; for no evidence has yet been obtained that the passage of an electric current through a gas or metal is accompanied

by a permanent alteration of the atoms of matter through which the current passes, although there is little doubt the current is carried in part at least by the electrons liberated from the atoms.

The first definite evidence of the transformation of matter was obtained from a study of the processes occurring in radioactive substances. The writer and Mr. Soddy in 1903 put forward the theory that the radiations from active matter accompanied a veritable transformation of the atoms themselves. The correctness of this theory as an explanation of radioactive phenomena is now generally accepted. As an illustration of these processes, consider the transformation of the radioactive element uranium. The series of substances which arise from the transformation of uranium are shown clearly in the diagram (Fig. 12). The best known of these elements is radium, which will be

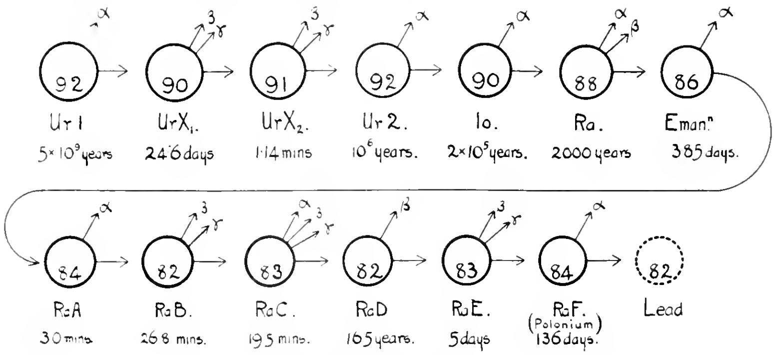


FIG. 12. SUCCESSIVE SUBSTANCES PRODUCED BY THE TRANSFORMATION OF THE URANIUM ATOM.

taken as a typical example of a radioactive substance. Radium differs from an ordinary element in its power of spontaneously expelling alpha particles with very great speed. This property is ascribed to an inherent instability which is not manifest in the atoms of ordinary elements. A small fraction of the radium atoms—about one in 100,000 million—break up each second with explosive violence expelling a fragment of the atom—the alpha particle—with very great speed. The residue of the atom is lighter than before and becomes the atom of an entirely new substance, which is called the radium emanation. The atoms of the latter are far more unstable than those of radium, for half of them break up in 3.85 days, while half of the radium atoms break up in about 2,000 years. After the loss of an alpha particle, an atom of the emanation changes into an atom of a new substance radium A, which behaves as a solid. Radium A is very unstable, half of it breaking up in 3 minutes with the emission of an alpha particle, and gives rise to radium B. The latter differs from the substances already mentioned in the nature of its radiation, for it emits only beta rays but no alpha rays. Notwithstanding this fact, it is transformed according to the same law as an alpha ray substance, and gives rise to an entirely distinct element,

radium C. In the transformation of the latter, not only are swift alpha rays emitted but also beta rays of great speed. There is some evidence, however, that the substance called radium C is complex, and that the alpha and beta rays arise from two distinct substances.

The successive substances arising from radium C are radium D, radium E and radium F. The two former, like radium B, emit only beta rays; the latter, known generally as polonium, emits only alpha rays. It is believed that the sequence of changes ends with the transformation of radium F, which is supposed to change into the well-known non-radioactive element lead.

According to the transformation theory radium, like all other radioactive products, must be regarded as a changing element, but one whose rate of transformation is very slow compared with its successive products. Boltwood showed experimentally that radium is half transformed in about 2,000 years, and a quantity of radium would practically have disappeared as such in 100,000 years. In order to account for the continued existence of radium in the earth, it is necessary to suppose that it is steadily produced from some other element. Boltwood showed that the parent substance is a radioactive element called ionium, which is itself derived from the transformation of uranium. A quantity of ionium, entirely freed from radium, will grow radium at a slow but constant rate. The primary element of the ionium-radium series is uranium, which we can calculate should be half transformed in 5,000 million years—a period probably long compared with the age of many of the minerals in which uranium is found.

The complete sequence of changes in the uranium-radium series is shown in the diagram. The nature of the radiation and the half period of transformation are added for each element. In addition to uranium, there are two other radioactive elements, thorium and actinium, which are transformed with the appearance of a number of new substances. The time at my disposal, however, is too short to discuss these changes in detail. Thorium is known to be a primary element whose radioactive life is even longer than uranium, but actinium is believed to be a branch descendant from some point of the uranium series, and is thus to be regarded as a product of that element. In all, thirty-four of these radioactive substances have been discovered, and the position of each in the three main radioactive series has been determined.

Each of these new substances is to be regarded as a distinct chemical element in the ordinary sense, but differs from ordinary stable elements in the spontaneous emission of special radiations which accompanies the disintegration of the atoms. The radioactive substances are thus transition elements which have a limited life and which carry within themselves the seeds of their own destruction. Not only are these transition elements distinguished by their types of radiation but also by

their distinct physical and chemical properties. The extraordinary differences in properties which sometimes exist between a product and its parent substance are well illustrated by the comparison of radium and its product, the emanation. Radium is a solid element of atomic weight 226, which has chemical properties allied to barium but is capable of separation from it. The emanation is a heavy monatomic gas of atomic weight 222, which by its absence of chemical properties is allied to the well known group of rare gases, helium, argon, neon, xenon and krypton. In some cases, the elements show almost identical physical and chemical properties with those of known elements, although they differ from them in their atomic weight and radioactivity. For example, radium B appears to be identical in ordinary chemical and physical properties with lead although its atomic weight, 214, is quite distinct from lead, 207. The probable explanation of this, at first sight, remarkable identity will be discussed later.

It is of interest to note that in the majority of cases a radioactive element breaks up in only one way which is characteristic for all the atoms of that element, and gives rise to only one new product. The work of Fajans and Marsden, however, has clearly shown that in the case of radium C and the corresponding products in the thorium and actinium series, the atoms break up in two distinct ways and give rise to two distinct radioactive elements. It has already been pointed out that actinium is in reality one of these side or branch products. It is supposed that uranium X breaks up in two distinct ways, the smaller fraction giving rise to actinium. The evidence, however, on this point, is not yet complete.

The radioactive elements are in some respects more interesting and important than stable elements, for, in addition to the ordinary physical and chemical properties, they possess the radioactive property which allows us to study the mode and rate of transformation of their atoms.

It may be asked what is the essential difference between radioactive changes and ordinary chemical changes. In the radioactive changes we are not dealing with the dissociation of molecules into atoms but an actual disruption of the chemical atom. The disintegration of any given element appears to be a spontaneous and uncontrollable process which, unlike ordinary chemical changes, is quite unaffected by the most drastic changes in temperature or by any other known physical or chemical agency.

The radioactive changes differ entirely from chemical changes not only in the peculiar character of the emitted radiations but also in the enormous emission of energy. It can be simply shown that the energy emitted from a radioactive substance which expels alpha particles is several million times greater than the energy emitted from an equal weight of matter in any known chemical reaction. This emission of energy is mainly to be ascribed to the conversion of the energy of

motion of the swift alpha and beta particles into heat, and is thus in a sense a secondary effect of the radiations. The enormous emission of energy is most simply illustrated by considering the case of the radium emanation together with its swiftly changing products, radium A, radium B and radium C. The heating effect of a given volume or weight of this gas has been accurately determined. From the data, it can be calculated that one pound weight of the emanation would emit heat energy initially at the rate of 23,000 horse power. The rate of emission decreases with the time, falling successively to half value after intervals of 3.85 days. During the life of the emanation the total energy emitted corresponds to an engine working at 128,000 horse power for one day. Such a quantity of emanation would be an enormously concentrated source of power, for the total energy emitted is many million times greater than for an equal weight of the most powerful known explosive.

The emission of energy from radioactive substances does not controvert the law of the conservation of energy; for the energy is derived from the atom itself where it exists in kinetic or potential form. We shall see later that the atom is believed to consist of a large number of positively and negatively charged particles which are collected in a very small volume and held together by intense electrical forces. Such an idea of atomic structure involves the necessity of a large store of energy resident in the individual atom. The great emission of energy from a radioactive substance like the emanation illustrates in a striking way the enormous reservoir of energy that must exist in the atoms themselves; for there is every reason to believe that an equivalent amount of energy is present in the atoms of the common heavy elements. This store of energy ordinarily does not manifest itself and is not available for use. It is only when there is a drastic rearrangement of the atom resulting from an atomic explosion that part of this store of energy is liberated.

It must be borne in mind that the processes occurring in radioactive matter are spontaneous and uncontrollable. There is at present no evidence to indicate that we shall be able in any way to influence radioactive changes. We are at present only able to watch and investigate this remarkable phenomenon of nature without any power of controlling it. In a recent book, H. G. Wells has discussed in an interesting way some of the future possibilities if this great reservoir of energy resident in the atoms were made available for the use of man. This will only be possible on a large scale if we are able in some way to alter the rate of radioactive change and to cause a substance like uranium, or thorium, to give out its energy in the course of a few hours or days instead of over a period of many thousands or millions of years. The possibility, however, of altering the rate of transformation of

radioactive matter, or of inducing similar effects in ordinary matter, does not at present seem at all promising.

Structure of the Atom

We have seen that in recent years a number of methods have been devised for determining with precision the actual weight of any atom of matter. If it be assumed that in the solid state the atoms, or molecules, of matter are in close contact, it is a simple matter to deduce the diameter of the atom. This varies slightly for different atoms, but on an average comes out to be about one hundred-millionth of a centimeter. It is necessary, however, to be cautious in speaking of the diameter of the atom. The term "diameter of the sphere of action" of the atom is preferable, for it is not at all certain that the actual atomic structure is nearly so extensive as the region through which the atomic forces are appreciable.

Even before the discovery of the electron, the general idea had been suggested that the atom was an electrical structure composed of negatively and positively charged particles held in equilibrium by electrical forces. Such ideas had been proposed and developed by Larmor and Lorentz in order to explain the electrical and optical properties of the atom. The proof that the negative electron was an independent unit of the structure of the atom gave a great impetus to the formation of more concrete ideas on atomic structure. There was one important difficulty, however, that arose at the outset. While negative electricity had been shown to exist in independent units of very small apparent mass, the corresponding unit of positive electricity was never found associated with a mass less than the atom of hydrogen. All attempts to show the existence of a positive electron of small mass, which is a counterpart of the negative electron, have resulted in failure, and it seems doubtful whether such a positive electron exists. The rôle played by positive electricity in the atom was thus a matter of conjecture. In a paper called "Æpinus Atomized," the late Lord Kelvin considered an atom to consist of a uniform sphere of positive electrification, throughout which negative electricity was distributed in the form of discrete electrons. In order to make such an atom electrically neutral, it is, of course, necessary that the positive charge should be equal and opposite to the charge carried by the electrons. This idea of the structure of the atom was taken up and developed with great mathematical skill by Sir J. J. Thomson. He investigated the constitution of atoms containing different numbers of electrons, and showed that such model atoms possessed properties very similar to those shown by the actual atoms. The Thomson atom proved for many years very useful in giving a concrete idea of the possible structure of the atom, and had the great advantage of being amenable to calculation.

The rapid advance of science in the last decade has provided us

with new and powerful methods of attack on this problem, and has allowed us to distinguish to some extent between various theories of atomic structure. One of these methods depends on the study of the deflection of swiftly moving bodies like alpha and beta particles in their passage through matter. It is found that these rays are always scattered in their passage through matter, *i. e.,* a narrow pencil of rays opens out into a diffuse or scattered beam. The alpha and beta particles move so swiftly that they are actually able to pass through the structure of the atom and are deflected by the intense forces within the atom. Geiger first drew attention to a very unexpected effect with alpha particles. When a pencil of alpha rays falls on a thin film of gold, for example, the great majority of the particles pass through with little absorption. A few, however, are found to be so scattered that they are turned back through an angle of more than a right angle. Taking into consideration the great energy of motion of the alpha particle, such a result is as surprising as it would be to a gunner if an occasional shot at a light target was deflected back towards the gun. It was found that these large deflections must result from an encounter with a single atom. The occasional sudden deflection of an alpha particle is well illustrated in one of the later photographs of the trail of an alpha particle obtained by Mr. C. T. R. Wilson, and shown in Fig. 13. It is

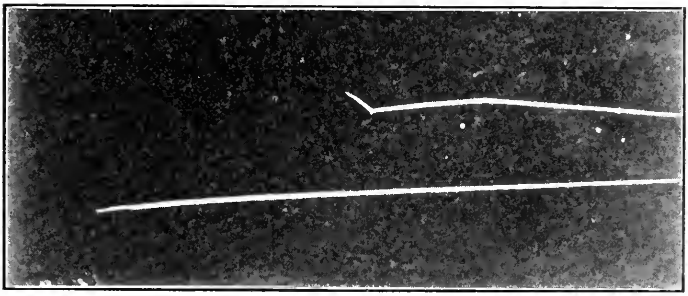


FIG. 13. TRACK OF ALPHA PARTICLES SHOWING SHARP DEVIATIONS (WILSON).

seen that the rectilinear path of the particle suffers two sharp bends, no doubt resulting in each case from a single close encounter with an atom. In the sharp bend near the end a slight spur is seen, indicating that the atom was set in such swift motion by the encounter with the alpha particle that it was able to ionize gas at a short distance. If the forces causing the deflection were electrical, it was at once evident that the electric field within the atom must be exceedingly intense. The distribution of positive electricity assumed in the Thomson atom was much too diffuse to produce the intense fields required. To overcome this difficulty, the writer inverted the rôle of positive electricity. Instead of being distributed through a sphere comparable in size with the sphere of action of the atom, the positive electricity is supposed to be

concentrated in a very minute volume or nucleus, and the greater part of the mass of the atom is supposed to be resident in this nucleus. The latter is supposed to be surrounded by a distribution of negative electrons extending over a distance comparable with the diameter of the atom as ordinarily understood. On this point of view, the alpha particle is the minute nucleus of the helium atom, which has lost its two external electrons. In this type of atom, the large deviations of the alpha particle take place when it passes through the intense electric field close to the nucleus of the colliding atom. The nearer it passes to the nucleus, the greater the deflection of the particle. Assuming that the forces between the alpha particle and the nucleus of the colliding atom are mainly electrical and vary according to an inverse square law, the alpha particle describes a hyperbolic orbit round the nucleus, and the relative number of alpha particles deflected through different angles can be simply calculated.

It was thus possible to test this theory of atomic structure by actual experiment. This was undertaken by Geiger and Marsden in a very important but difficult investigation. They examined the relative number of alpha particles scattered through various angles by their passage through thin films of matter, *e. g.*, aluminium, silver and gold, by actually counting the alpha particles by means of the scintillations on a zinc sulphide screen. The experimental results were found to be in very good accord with the theory, while Darwin, in addition, showed that any other law of force except the inverse square was incompatible with the observations.

From these results, it is a simple matter to show that the radium of the nucleus of the gold atom can not be greater than 3×10^{12} cm.—an exceedingly small distance and only about one ten-thousandth part of the diameter of the atom. While the results thus indicated that the nucleus of a heavy atom was of minute dimensions, it was of interest to see whether a still lower limit could be obtained for lighter atoms. On the theory, the helium atom has a nucleus of two unit positive charges, and the lighter atom, hydrogen, should have a nucleus of only one unit. When an alpha particle passes through hydrogen gas, there should be occasional very close encounters between the particle and nucleus of the hydrogen atom. Since the mass of the hydrogen atom is only one quarter of that of helium, it is to be anticipated that the former should be set in very swift motion by a close collision with an alpha particle, and in special cases should be given a velocity 1.6 times greater than that of the colliding alpha particle, and should travel four times as far. Such swiftly moving hydrogen nuclei were actually observed by Marsden with the scintillation method when a pencil of alpha rays passed through hydrogen, and they were found to travel, as the theory predicted, about four times further than the alpha particle itself. Since the energy gained by the hydrogen nucleus depends on the closeness

of its approach to the alpha particle, it can be simply calculated that the centers of the nuclei must have passed within 10^{-13} cm. of each other. This is an extraordinarily small distance, even smaller than the diameter of the electron itself. It is thus clear that the nuclei of hydrogen and of helium must be exceedingly minute. It should be borne in mind that such observations only give a *maximum* limit to the size of the nucleus, and there is no experimental evidence against the view that the nucleus of the hydrogen atom may not actually prove to be minute in volume compared even with the negative electron. If this be the case, it appears probable that the hydrogen nucleus is the *positive electron* and that its great mass compared with the negative electron is due to the greater concentration of its charge. According to modern theory, the electrical mass of a charged particle varies inversely as its radius. The greater mass of the positive than of the negative electron would thus be explained if its radius were only 1/1800 of that of the negative electron, viz., about 10^{-16} cm.

There is no evidence to contradict this point of view, and its simplicity has much to commend it. In viewing the essential differences exhibited by positive and negative electricity in connection with matter and the obvious asymmetry of the distribution of the two electricities in the atom, one is driven to the conclusion that there is a fundamental distinction between positive and negative electricity. Since the unit of positive charge is identical in magnitude with the unit of negative charge, the only possible difference is the mass of the two units, and this on modern views is mainly dependent on the dimensions or degree of concentration of the electricity in these fundamental entities.

If we take the view that the hydrogen nucleus is the positive electron, it is to be anticipated that the nuclei of all atoms are built up of positive and negative electrons, the positive electricity being always in excess, so that the nucleus shows a resultant positive charge. The mass of the atom will depend mainly on the number of the massive positive electrons in the nucleus, although it will be affected to a slight extent by the number of the lighter negative electrons involved in the structure of the whole atom. The mass of the atom will no doubt be influenced also by the distribution of the positive and negative electrons in the nucleus, for these must be packed so closely together that their field must interact. As Lorentz has shown, the mass of a number of closely packed electrons is not necessarily the same as the sum of individual masses of the component electrons. Taking such factors into account, we should not necessarily expect the mass of all atoms to be nearly an integral multiple of the mass of the hydrogen atom, although it is known that in a number of cases such a relation appears to hold fairly closely.

The appearance of a helium atom in such a fundamental process as the transformation of radioactive atoms indicates that helium is one

of the units, possibly secondary, of which the nuclei of the heavy atoms are built up. In course of its successive transformations, a uranium atom loses eight helium atoms, a thorium atom six, and an atom of actinium five. The probability that helium is one of the units of atomic structure not only in the case of radioactive atoms but for ordinary atoms is strengthened by the fact that the atomic weights of a number of elements differ by about four units.

The fact that the helium nucleus survives the intense disturbance resulting in its violent ejection from a radioactive atom suggests that it is a very stable configuration. On the views discussed, it is natural to suppose that the helium nucleus of atomic weight about four is made up of four positive electrons united with two negative electrons. No doubt it is difficult to understand why such a system should hold together, but it must be remembered that we have no information as to the nature of magnitude of the forces existing at such minute distances as are involved in the structure of the nucleus.

We have so far assumed without proof that while the nucleus of an atom carries a resultant positive charge, negative electrons are also present. The main evidence on this point comes from a study of the radioactive elements. A substance which breaks up with the emission of swift electrons (beta rays), but no alpha particles, suffers disintegration according to the same laws and gives rise to a new element in the same way as when an alpha particle is lost. It seems necessary to suppose from a number of lines of evidence that a transformation which is accompanied by the emission of primary beta particles must have its origin in the ejection of a negative electron from the nucleus itself, or from a point very close to the nucleus.

There are no means at present of deciding definitely the relative number of positive and negative units composing the nucleus, except possibly from a consideration of the atomic weight of the atom in terms of hydrogen. It is, however, premature to discuss such questions until more information is obtained as to the structure of the nucleus and the effect of concentration and distribution of the component electrical charges on its apparent mass.

Charge Carried by the Nucleus

We are now in a position to consider a very important question, viz., the magnitude of the positive charge carried by the atomic nucleus. Since an atom is electrically neutral, the negative charge carried by the exterior distribution of electrons in the structure of the atom must be equal and opposite to the resultant positive charge carried by the nucleus. The electrical charge is most conveniently expressed in terms of the number of the fundamental units of charge in the nucleus. Since the charge carried by the electron is one unit, the charge on the nucleus of the atom may be expressed numerically by the number

of electrons exterior to the nucleus. Several methods of attack on this problem have been suggested. Sir J. J. Thomson showed that the scattering of Röntgen rays in passing through the atoms of matter must depend on the number of electrons composing the atom. By assuming that each electron scattered is an independent unit, an expression for the scattering was found in terms of the number of electrons in the atom. By comparison of the theory with experiment, Barkla deduced that for many elements the number of electrons in an atom was approximately proportional to its atomic weight and numerically equal to about one half of the atomic weight in terms of hydrogen.

The charge in the nucleus can also be directly determined from the experiments on scattering of alpha rays, to which attention has previously been drawn. Geiger and Marsden found that the large angle scattering of alpha rays in passing through different substances was proportional per atom to the square of its atomic weight. This showed that the positive charge on the nucleus was approximately proportional to the atomic weight at any rate for elements of atomic weight varying between aluminium and gold. By measuring the fraction of the total number of alpha particles which were deflected through a definite angle in passing through a known thickness of matter, the charge on the nucleus was deduced directly. The number of positive units of charge on the nucleus, which is equal to the number of external negative electrons, was found to be expressed by about one half of the atomic weight in terms of hydrogen. The results obtained by two entirely distinct methods of attack are thus in good accord and give approximately the magnitude of this important atomic constant.

It is obvious, however, that the deduction that the number of units of charge on the nucleus is half the atomic weight, must be only a first approximation to the truth even in the case of the heavier atoms. It has already been pointed out that the nucleus of the helium atom of atomic mass four must carry two unit charges, for it is difficult to believe that any of the exterior electrons of helium can remain attached after its violent expulsion from the atom and its subsequent passage through matter. If this be the case, the nucleus of the hydrogen atom of atomic mass one, must carry one unit charge. Van den Broek and Bohr have suggested that the charge on the nucleus might be equal to the actual number of the element when all the known elements are arranged in order of increasing atomic weight. This is in excellent accord with the experiments of scattering and removes a difficulty in regard to the lighter atoms. Taking this view, the nucleus charge is for hydrogen 1, helium 2, lithium 3, carbon 6, oxygen 8, etc. The simplicity of this conception has much to commend it.

During the last year a new and powerful method of attack on this fundamental problem has been developed by Moseley by the study of X-ray spectra. In 1912, Laue found that X rays showed obvious in-

terference or diffraction effects in their passage through crystals, thus proving definitely that the X rays consist of very short waves analogous to those of light. W. H. Bragg and W. L. Bragg and Moseley and Darwin found that the reflection of the X rays from crystals provided a very simple method of measuring the wave length of the X rays when the spacing of the atoms in the crystal is known. If the X rays give a spectrum containing some bright lines, the wave-lengths of the latter can be simply determined. The work of Barkla has shown us that an X radiation, characteristic of each element, is excited under certain conditions when X rays fall upon it. The penetrating power of this characteristic radiation increases rapidly with the atomic weight of the radiator. In heavy elements, another type of characteristic radiation makes its appearance. These two types of characteristic radiation have been called by Barkla the "K" and "L" radiations respectively. These radiations can be excited either by X rays of suitable penetrating power or by direct bombardment of the element by cathode rays in a vacuum tube. Moseley made a systematic examination of the X-ray spectra of a great majority of the elements. For this purpose,

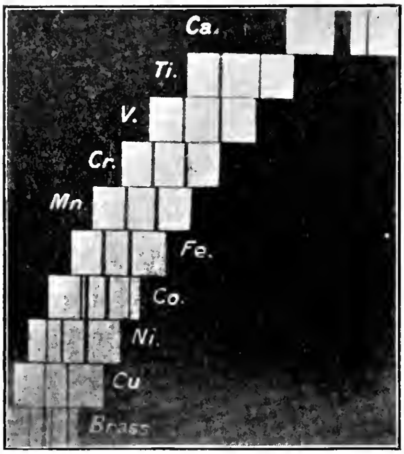


Fig. 14. X-ray Spectra of Successive Elements (Moseley). The additional lines in spectrum of Co and Ni are due to impurity. Brass shows the combined spectra of copper and zinc.

the elements examined were bombarded by cathode rays, and the spectrum of the radiation examined by reflection from a suitable crystal. He found that the spectra of the "K" radiation from elements varying in atomic weight from aluminium to silver were all similar in type, consisting mainly of two strong lines.[2] An example of the spectrum obtained for a number of successive elements is shown in Fig. 14. It is seen that with increasing atomic weight, the wave-lengths of the corresponding lines diminish, not irregularly but by definite and well marked

[2] In later work Rawlinson and Bragg have found that each of these lines is in reality a very close double.

steps. Moseley found that for the K radiation the frequency of the radiation was proportional to $(N\text{-}a)^2$ where N was a whole number which varied by unity in passing from one element to the next of higher atomic weight and a constant about unity. From silver to gold, the spectra given by the L radiations of elements were compared. These spectra consist of about five lines, of which two are relatively very strong. It was found again that the spectra were similar in type and that the frequency of a given line diminished by definite steps in passing from one element to another. The frequency of the radiation in this case was proportional to $(N\text{-}b)^2$ where b was a constant and N a whole number. Moseley concluded that the value of N in these expressions was the *atomic number, i. e.,* the number of the element arranged in order of increasing atomic weight. Taking aluminium as the 13th element, he found that succeeding elements were expressed by the value of N 14, 15, 16, 17, etc., up to 77 for gold.

There appears to be little doubt that the X-ray spectrum of an element arises from the vibrations of the rings of electrons deep in the atomic structure outside the nucleus. Quite apart from the very interesting question of the mode of origin of these very high frequency spectra, it is seen that the fundamental modes of vibration of the distribution of electrons are simply connected with the square of a number, which varies by unity in passing from one element to the next. There appears to be no doubt that the atomic number represents the number of units of positive charge carried by the nucleus, which on account of the atomic nature of electricity can only vary by whole numbers and not by fractions.

It is obvious that the study of X-ray spectra reveals at once whether any atomic number is missing, and also affords a remarkably simple method of settling the number of elements possible in the rare earth group about which there has been so much difference of opinion. Moseley concluded that from aluminium to gold, only three possible elements were missing which should have atomic numbers 43, 61, 75, and only one element of number 61 appears to be missing in the rare earth group. The frequencies of the X-ray spectra of these missing elements can be calculated with certainty, and these data should prove an invaluable aid in a search for these missing elements. It has long been known that nickel and cobalt occupy an anomalous position in the periodic table when arranged according to atomic weights. This difficulty is now removed, for Moseley found that when arranged in order of nucleus charge, both elements fall into the position to be expected from their chemical properties.

Nucleus Charge and Chemical Properties

It is established by the work of Moseley that the elements can be defined by their nucleus charge, and that probably elements exist which

have all the nucleus charges from 1 for hydrogen to 92 for lead. There is, however, another very important consequence that follows from this conception of the atom. Disregarding for a moment the atomic weight which depends mainly on the structure of the nucleus, the main physical and chemical properties of the atom are determined by the nucleus charge and not by the atomic mass. This must obviously be the case, for the number and distribution of electrons round the nucleus is determined by the electric forces between the electrons and the nucleus, and this is dependent on the magnitude of the nucleus charge which may be regarded as a point charge. Without entering into the difficult question of the actual distribution of the exterior electrons in any atom, it is obvious that the number and position of the outlying electrons of the atomic structure, which probably mainly influence the chemical and physical properties of the atom, are determined by the charge on the nucleus. No doubt if the electrons are in motion, their positions relative to the nucleus and possibly also their rates of vibration will be slightly influenced by the mass of the nucleus as well as its charge, but the general evidence indicates that this effect must be very small.

We thus see that there is in the structure of every atom a quantity which is more fundamental and important than its atomic weight, viz., its nuclear charge. It is known that the variation of the atomic weights of the elements with atomic number, while showing certain well-marked relationships, shows no definite regularity. From the point of view of the nucleus theory, the atomic weight of an element, while in some cases approximately proportional to its atomic number, is in reality a complicated function of the actual structure of the nucleus. The question why the atomic mass should not necessarily be proportional to the atomic number has already been discussed. While the main properties of an atom are controlled by its nuclear charge, the property of gravitation and also that of radioactivity are to be ascribed mainly, if not entirely, to the nucleus.

Radioactive Elements and the Periodic Series

Since the nucleus charge of an atom determines the main physical and chemical properties of an atom, it is possible that elements may exist of equal nuclear charges but different atomic weights. For example, if it were possible to add a helium nucleus to the nucleus of another atom, it would increase the nuclear charge by two and the mass by about four; if instead of the helium nucleus two hydrogen nuclei were added, the charge would be the same but the mass of the resulting atom two units less than with helium. In such a case, two atoms would be possible of identical nuclear charge but different atomic weights. In a similar way, it may be possible for elements to exist of the same atomic mass but *different* nuclear charges. This would be brought about by the loss or gain of one or more negative electrons in the nucleus.

The study of radioactive elements has in the last year thrown a flood of light not only on this problem but on the underlying meaning of the periodic law of the elements. Russell, Fajans and Soddy independently put forward a remarkable and important generalization in regard to the change of chemical properties of the successive products of transformation of the primary radioactive elements. This generalization can be very simply expressed in terms of the usual arrangement of the elements in groups according to the periodic law. It is found that after a transformation in which alpha particles are expelled, the resulting element has chemical properties which shift its place two groups lower in the direction of diminishing mass. On the other hand, the element resulting from a beta ray transformation shifts one place in the opposite direction. For example, radium, which is in group II., changes after loss of an alpha particle into the emanation into group 0, which included all the inert gases of the helium-argon type. The emanation after loss of another particle becomes radium A, which belongs to group VI., and this in turn becomes radium B belonging to group IV. Since radium B is transformed by the loss of a beta particle, the resulting element radium C takes up a position in group V. By this simple rule, it has been found possible to define the essential chemical properties of all known radioactive elements. It was found that on this theory one element was missing in the general scheme. This element was discovered a few weeks later by Fajans and Göhring, and found to have the general chemical properties predicted for it.

This generalization is capable of a very simple explanation on the nucleus theory. The loss of an alpha particle of charge 2 *lowers* the nuclear charge of the resulting elements two units; the loss of a beta particle, which carries a unit negative charge, *raises* the nuclear charge by one unit. In other words, the atomic number of an element shifts two units lower after loss of an alpha particle and shifts one unit higher after loss of a beta particle.

The atomic numbers of the elements in the uranium-radium series can be simply deduced from this rule if the atomic number of one element is known. We shall see later that the atomic number of radium B is 82 and identical with that of lead. The actual atomic numbers of the various elements are given in the circles representing the atoms in Fig. 12. It is seen that uranium, the heaviest known element, has an atomic number 92, while the elements radium B, radium D and the end product, which is believed to be lead, have the same atomic number, viz., 82. The evidence of the correctness of this striking conclusion will now be discussed.

As a result of a careful examination of the radioactive substances, it has been found that in a number of cases elements, which are of different atomic weight and exhibit different radioactive properties, yet

show identical general physical and chemical behavior. For example, the elements radium B, radium D and lead, of atomic weights 214, 210, and 207, respectively, are so closely allied in chemical and physical properties that all attempts to separate a mixture of any two of them have failed completely. This would be explained if the nuclear charges were identical for those elements, as the generalization, already referred to, indicates. If this be the case, they should give identical spectra under similar conditions. Unfortunately the elements radium B and radium D are in too small quantity to determine their ordinary light spectra, but we can compare the X-ray spectrum of lead with that given by radium B under the excitation of its own beta rays. Experiments of this kind were recently made by Dr. Andrade and the writer, and the two spectra were found to be identical within the limits of experimental error. It is to be anticipated that their light spectra would also prove to be identical, or nearly so, for, as previously pointed out, the effect of the mass of the nucleus on the spectrum is probably very small.

The fact that the atoms of these three elements are not identical as regards mass or radioactive properties, shows that the structure of the nucleus is different in each case.

There is another important deduction that should be mentioned. The end product of the uranium-radium series is an inactive element which has long been considered to be lead, but it has been difficult to verify this conclusion by direct experiment. We have seen that the end product has the same atomic number as lead, but should have an atomic weight about 206 instead of 207 as found for ordinary lead. In a similar way, it has been concluded by Soddy and Fajans that the end product of thorium has the same atomic number as lead, but should have an atomic weight about 208.5. In order to test these remarkable conclusions, experiments are now in progress by a number of investigators in different countries to examine whether the lead always found in radioactive minerals and which presumably has partly, if not wholly, a radioactive origin, shows the same atomic weight as ordinary lead. Soddy has already found evidence that there is a distinct difference in the atomic weights in the direction predicted by the theory.[3]

The question naturally arises whether some of the ordinary elements may not prove to be a mixture of two, or even more, of these "isotopes," as they have been termed. Unless the component isotopes are present in different proportion in different natural sources of the element, it will be difficult to settle this problem by ordinary chemical methods.

[3] Since the delivery of this lecture, similar conclusions have been reached by the experiments of Richards in Cambridge and Hönigschmid in Vienna. There still, however, remains some doubt as to the actual difference in atomic weight of uranium lead, thorium lead and ordinary lead. A very promising beginning has thus been made on the attack of this most important and fundamental problem.

There is one element, however, besides lead, about which interesting evidence has been obtained on this point. Sir J. J. Thomson found by examining the deflection of the positively charged particles produced by an electric discharge through the rare gas, neon, that two elements were present of atomic weights about 20 (neon) and 22. Aston was able by diffusion experiments to separate partially the two components of neon and to show that they differed in density, but failed in attempts to separate them by fractional distillation in charcoal cooled by liquid air. Such results are to be anticipated if neon is a mixture of two isotopes, *i. e.*, elements of identical nuclear charges but different atomic weights.

It is obvious that this new point of view will result in a systematic examination of the elements to test for the possible presence of isotopes, and thus give an additional reason for the accurate determination of atomic weights for elements obtained from widely different sources.

Distribution of Electrons in the Atom

It is seen that the nucleus theory of the atom offers a simple explanation of many important facts which have been brought to light in recent years, and for this purpose it has not been necessary to make any special assumptions as to the actual structure of the nucleus, or of the way in which the external electrons are distributed. The investigation of the latter problem is beset with many difficulties; for an electron is attracted towards the nucleus, and even if it is in orbital motion, it must on the electromagnetic theory lose energy by radiation and ultimately fall into the nucleus. It appears likely that this difficulty is in reality due to our ignorance of the conditions under which an electron radiates energy. According to the views outlined in this lecture, the hydrogen atom has the simplest possible structure, for it consists of a nucleus of one unit charge and one negative electron. The question naturally arises how such a simple structure can give rise to the complex spectrum observed for hydrogen. This problem has been attacked in a series of remarkable papers by Bohr, who concludes that the complexity of the spectrum is not due to the complexity of the atomic structure but to the variety of modes in which an electron can emit radiation. Suppose, for example, that a hydrogen atom has lost its negative electron. Bohr supposes that an electron falling towards the positively charged nucleus may occupy temporarily any one of a number of stationary positions fixed relatively to the nucleus. In falling from one stationary state to another, radiation is emitted of a definite frequency which is connected with the difference of potential energy E of the electron in the two stationary states by $E \cdot h$ where h is Planck's fundamental constant. On this hypothesis, he has been able to account for the series spectra of hydrogen and to deduce directly from the theory the value of Balmer's constant which plays such an important

part in the spectra of all atoms. In a similar way, the helium atom is supposed to consist of a nucleus of two unit charges surrounded by two electrons. On the theory, the spectrum of helium is connected in a very simple way with that of hydrogen. Bohr also pointed out that the Pickering series of spectral lines observed in certain stars which were originally attributed to hydrogen must be ascribed to helium. This conclusion has since been strongly supported by the direct experiments of Fowler and Evans. In a similar way, Bohr described the possible distribution of electrons in several of the lighter atoms and also discussed the structure of the hydrogen molecule, which is composed of two hydrogen nuclei and two electrons. The heat of combination deduced for the theoretical molecule is in fair accord with experiment. He found that two helium atoms were unable to unite to form a molecule—in agreement with a well-known property of this gas.

While there is room for much difference of opinion as to the interpretation of the rather revolutionary assumptions made by Bohr to explain the structure of the simple atoms and molecules, there can be no doubt of the great interest and importance of this first attempt to deduce the structure of the simple atoms and to explain the origin of their spectra. The agreement of the properties of such theoretical structures with the actual atoms is in several cases so remarkable that it is difficult to believe that the theory is not in some way an expression of the actual facts. While much work will be necessary before we can hope to understand the structure of any but the simplest atoms, a promising beginning has been made in the attack on this most difficult and fundamental of problems.

There seems to be little doubt that the more marked physical and chemical properties of an atom are to be attributed to a few outlying electrons in the atomic structure. The position and number of these "valency" electrons, as they have been termed by Stark, are defined by the magnitude of the nucleus charge. It has previously been pointed out that the loss of an alpha particle from a radioactive atom changes the position of the element two groups lower in the periodic table, while the loss of a beta particle raises it one group higher. Consequently it follows that the loss or gain of a unit charge from the nucleus of an atom causes it to change its position from one group to the next. If, for example, we follow the chemical properties of successive elements when the nucleus charge increases by unity, we soon reach an element which belongs to the same group as the first, although of much higher atomic weight. We must consequently conclude that the number and position of the outlying electrons in the structure of the atom passes through successive changes which are regularly repeated with increasing atomic weight. Quite apart from any detailed knowledge of the electronic distribution of atoms, the regular recurrence of elements of

similar chemical properties with increasing atomic weight is to be anticipated on the general theory that an atom is an electrical structure.

Evolution of the Elements

It has long been thought probable that the elements are all built up of some fundamental substance, and Prout's well-known hypothesis that all atoms are composed of hydrogen is one of the best known examples of this idea. The evidence of radioactivity certainly indicates that the heavy radioactive elements are in part composed of helium, for an atom of the latter appears as a result of many of the radioactive transformations. No definite evidence, however, has been obtained that hydrogen appears as a result of such transformations; but as previously pointed out, helium may prove to be an important secondary unit in the structure of heavy atoms. While we have thus undoubted evidence of the breaking up of heavy atoms, no indication has yet been observed that the radioactive processes are reversible under ordinary conditions. Many investigations have been made to test whether new elements appear in strong electric discharges in vacuum tubes. While some of the results obtained are difficult of interpretation, no reliable evidence has yet been adduced that one element can be transformed into another under such conditions.

The question of the evolution of the elements has been attacked from another side. Sir Norman Lockyer and others have suggested that the elements composing the star are in a state of inorganic evolution. In the hottest stars the spectra of hydrogen and helium predominate, but with decreasing temperature, the spectra becomes more complicated and the lines of heavier elements appear. On this view, it is supposed that the light elements combine with decreasing temperature to form the heavier elements.

There is no doubt that it will prove a very difficult task to bring about the transmutation of matter under ordinary terrestrial conditions. The enormous evolution of energy which accompanies the transformation of radioactive matter affords some indication of the great intensity of the forces that will be required to build up lighter into heavier atoms. On the point of view outlined in these lectures, the building up of a new atom will require the addition to the atomic nucleus of either the nucleus of hydrogen or of helium, or a combination of these nuclei. On present data, this is only possible if the hydrogen or helium atom is shot into the atom with such great speed that it passes close to the nucleus. In any case, it presumes there are forces close to the nucleus which are equivalent to forces of attraction for positively charged masses. It is possible that the nucleus of an atom may be altered either by direct collision of the nucleus with very swift electrons or atoms of helium such as are ejected from radioactive matter. There is

no doubt that under favorable conditions, these particles must pass very close to the nucleus and may either lead to a disruption of the nucleus or to a combination with it. Unfortunately, the chance of such a disruption or combination is so small under experimental conditions that the amount of new matter which is possible of formation within a reasonable time would be exceedingly small, and so very difficult of detection by direct methods. Very penetrating X rays or gamma rays may for similar reasons prove to be possible agencies for changing atoms. Although it is difficult to obtain direct evidence, I personally am inclined to believe that all atoms are built up of positive electrons—hydrogen nuclei—and negative electrons, and that atoms are purely electrical structures.

There can be little doubt that conditions have existed in the past in which these electrons have combined to form the atoms of the elements, and it may be quite possible under the very intense electrical disturbances which may exist in hot stars that the process of combination and dissociation of atoms still continues.

In these lectures, I have tried to give an idea of some modern views of the structure of the atoms and of the great variety of new and powerful methods which have been applied to the attack of this problem in recent years. We have seen that a heavy atom is undoubtedly a complex electrical system consisting of positively and negatively charged particles in rapid motion. The general evidence indicates that each atom contains at its center a massive charged nucleus or core of very small dimensions surrounded by a cluster of electrons probably in rapid motion which extend for distances from the center very great compared with the diameter of the nucleus. Such a view affords a reasonable and simple explanation of many important facts obtained in recent years, but so far only a beginning has been made in the attack on the detailed structure of atoms—that fundamental problem which lies at the basis of physics and chemistry.

WAR SELECTION IN WESTERN EUROPE

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France

EUROPE had no finer human stock than that of France, and no modern people has suffered more from the ravages of war and glory. The Gauls, as they appear in early history, were a Celtic race. Conquest made them Gallo-Roman. Later, especially in the north and east, their blood was strengthened by Teutonic strains—the Normans from Scandinavia and the Franks from Central Germany. In later days a large influx from Germanic Alsace has made German names common in French society.

Through reversal of selection by war, the men of France lost in stature, and the nation in initiative. But a good stock possesses power of recuperation, and regenerative processes have been evident in France for the last twenty years. Peace and security, industry and economy enable the natural forces of selection to operate. This means race regeneration. The nation had been sorely wounded by her own sons. She has been making a healthy recovery.[1]

In the Wiertz gallery in Brussels is a striking painting, dating from the time of Napoleon, called "A Scene in Hell" ("Une Scène dans l'Enfer"). It represents the great marshal with folded arms and face unmoved descending slowly to the land of the shades. Before him filling all the background of the picture, their faces expressing every form of reproach, are the men sent to death before their time by his

[1] "Land, money, tradition and prestige," says Professor Albert Léon Guerard ("French Civilization in the Nineteenth Century," 1912), "would be naught if the people had lost its soul. Their wealth would pass into stronger hands, and their prestige to contempt. Once, about twenty years ago, the French themselves wondered if it had not come to that. The cry of a decadence was raised by malevolent rivals, by sensationalists, by esthetics in quest of a new pose, by earnest patriots who had lost their star. When a belated echo of this reaches us now, how faint and strange and silly it sounds. For the one great asset of the French is their indomitable vitality. Even in wasteful conflict one can not fail to admire the evidence of power. In the twentieth century as ever before the French are among the pioneers.

"I do not see France as a goddess, austere and remote. I see her intensely human, stained with indecencies and blasphemies, scarred with innumerable battles, often blinded and stumbling on the way, but fighting on undismayed, for ideals which she can not always define. An old nation? A wounded nation? Perhaps, but her mighty heart is throbbing with unconquerable life."

unbridled ambition. Four millions there were in all, more than half of them Frenchmen. And behind the legions shown or hinted at, one seems to discern the millions on millions who might have been and are not—the huge widening wedge of the possible descendants of those who fell in battle, youth without blemish ("l'élite de l'Europe"), made "flesh for the cannon" in the rush of Napoleon's great campaigns.

These came from the farm, the workshop, the school, "the best that the nation could bring," men from eighteen to thirty-five years of age at first, but afterwards the older and the younger. Napoleon said:

> A boy will stop a bullet as well as a man.

Says Professor Haeckel:

> The more vigorous and well-born a young man is, the more normally constituted, the greater his chance to be slain by musket or magazine, the rifled cannon and other similar engines of civilization.

Says Seeck:

> Napoleon, in a series of years seized all the youth of high stature and left them scattered over many battlefields, so that the French people who followed them are mostly of smaller stature. More than once since Napoleon's time has the military limit been lowered.

In the career of Napoleon campaign followed campaign, against enemies, against neutrals, against friends. Conscription followed victory, both victory and conscription debasing the human species. Again conscription after conscription.

> Let them die with arms in their hands. Their death is glorious, and it will be avenged. You can always fill the places of soldiers. . . . A great soldier like me doesn't care a tinker's dam for the lives of a million men.

Still more conscription. After Wagram, France began to feel its weakness, the "Grand Army" being no longer the army which had fought at Ulm and Jena.

> Raw conscripts raised before their time and hurriedly drafted into the line had impaired its steadiness.

After Moscow, homeward

> amidst ever-deepening misery they struggled on, until of the six hundred thousand men who had proudly crossed the Nieman for the conquest of Russia, only twenty thousand famished, frostbitten, unarmed specters staggered across the bridge of Korno in the middle of December. . . . Despite the loss of the most splendid army marshalled by man, Napoleon abated no whit of his resolve to dominate Germany and discipline Russia. . . . He strained every effort to call the youth of the empire to arms . . . and 350,000 conscripts were promised by the senate. The mighty swirl of the Moscow campaign sucked in 150,000 lads of under twenty years of age into the devouring vortex. . . . The peasantry gave up their sons as food for cannon.

But

> many were appalled at the frightful drain on the nation's strength. . . . In less than half a year after the loss of half a million men a new army nearly as numerous was marshalled under the imperial eagles. But the majority were

young, untrained troops, and it was remarked that the conscripts born in the year of terror had not the stamina of the earlier levies. Brave they were, superbly brave, and the emperor sought by every means to breathe into them his indomitable spirit. (J. H. Rose.) Truly the emperor could make boys heroes, but he could never repair the losses of 1812. . . . Soldiers were wanting, youths were dragged forth. . . . To fill hell with heroes,

—in these words some one has summed up the life-work of Napoleon. "J'ai cent mille hommes de rente," "My income is a hundred thousand men," said Napoleon. But to a terrible degree he lived beyond his income.

French writers have been very frank in the discussion of national deficiencies and mistakes. They have wished to conceal nothing from France and therefore nothing from the world. Their admissions have been exaggerated by unfriendly critics. It has been claimed that modern France, with the other Latin nations, is a "decadent state," that she has passed her prime and is now in the weakness and sterility of old age, her place as the dominating force on the continent of Europe having been yielded to a younger and more aggressive power. If its strong strains are not wholly extirpated, peace and security will renew its youth. Decrepitude in a nation is due not to age, but to the operations of war, as we have several times insisted, followed by the loss of its best strains of blood and their replacement by recruiting from immigrants of the weaker races. Though France has suffered grievously from war, as a nation she has lost little from immigration and not much from emigration.

Certain features of French life have been indicated as evidences of injury from reversal of selection. The birthrate of France, already low, has been steadily falling. This is apparently a result of the survival of the cautious, for Napoleon's dashing grenadiers could hardly be imagined to limit their families for prudential reasons of economy. Indeed, the French in Canada, not affected by war, are notoriously fecund. Another evidence of the survival of the cautious is found in the relative lack of business enterprise in France. The gold hoarded in her stockings has been used mainly for international loans, rarely for business development, foreign loans yielding a higher interest with less personal responsibility. And the absence of factory towns emphasizes the fall in the birthrate, as in civilized nations a high rate of increase occurs mainly in industrial centers.

Edmond Demolins in a clever book asks: "In what constitutes the superiority of the Anglo-Saxon?" He finds his answer in the false standards in French life, in defects of training and of civic and personal ideals. The desire for seats in a government bureau and for similar safe places of routine and without initiative has been termed in Italy "Impiegomania," the "craze for sitting down." The eagerness to secure such positions is said to be a besetting sin of the youth of both Italy and France. But the fault may be due to over-centraliza-

tion of government, too many officials and too little opportunity in the provincial centers, rather than to any fault in the nature of the individual man. Nationalization of effort, whether through socialism or through "efficient organization," must contribute to the spread of "impiegomania."

If the strictures of Demolins be true in any degree, this may be the interpretation. Inferior standards are the work of inferior men. Great men there are in France, and these have persistently turned the nation's face toward the light since Demolins's book was written. War's effect has been to rob France of her due proportion of leaders, but not to dilute or to weaken the message of those who survive. The evolution of a race is always selective, never collective. Collective evolution among men or beasts, the movement upward or downward of the whole as a whole, irrespective of training or selection, is never a fact. As La Pouge has said:

> It exists in rhetoric, not in truth nor in history.

Another line of criticism of France finds its ablest exponent in Dr. Max Nordau, whose book on "Degeneration" aroused the attention of the world some twenty years ago. Nordau finds abundant evidences of degeneration in the art and literature of every land, all forms of eccentricity, pessimism and perversity being regarded as such. In France, such evidences he finds peculiarly conspicuous. The cause of this condition he ascribes to the inherited strain of an overwrought civilization. "Fin de siècle," "end of the century" is the catch-phrase expressing the weariness, mental, physical and spiritual of a race "tired before it was born." To Nordau, this theory adequately explains all eccentricities of French literature, art, politics or jurisprudence.

But in fact we have no knowledge of the existence of nerve-stress inheritance. In any event, the peasantry of France have not been subjected to it. Their life is hard, but not stressful; and they suffer more from monotony than from any form of enforced nerve-activity. The kind of degeneration Nordau pictures is not a matter of heredity. When not simply personal eccentricity, it is a phase of personal decay. It finds its causes in bad habits, bad training, bad morals, or in the desire to catch public attention for personal advantage. It has no permanence in the blood of the race. The presence on the Paris boulevards of eccentric painters, maudlin musicians, absinthine poets and sensation-mongers, proves nothing as to race degeneracy. When the fashion changes, they will change also. The "end of the century" is past and already the fad of "strenuous life" is blowing them away. Any man of any race withers in an atmosphere of vice, absinthe and opium. The presence of such an atmosphere may be a disheartening symptom, but it is not a proof of national decline. The ghastliest and

the most depraved of Parisian sensations are invented to meet the jaded fancy of gilded youth from across the sea.

A French cartoon more than a century old pictures a peasant ploughing in the field, hopeless and dejected, a frilled and cynical marquis on his back, tapping his gilded snuff-box. A recent one shows the peasant still at the plough and equally hopeless. The marquis is gone, but in his place sits a soldier armed to the teeth, who ought himself to be at the plough, while on the soldier's back rides the money-lender, colder and more crushing than the dainty marquis, for the money-lender is the visible exponent of the war-trader, most sinister and most burdensome of all purveyors of implements of destruction.

For more than forty years past France has lived under the shadow of war. The loss of Alsace-Lorraine cut a deep wound in French emotions as well as in French pride. The noble attitude of the lost provinces stimulated the natural determination for the "war of honor," the "war of revenge." But as time went on, it became more and more evident that such a war could never be successful. And after the collapse of the inflated militarism of Boulenger, and in view of the sordid failure of military honor as shown in the "Dreyfus case," the people of France began generally to doubt the righteousness as well as the wisdom of war against Germany. In 1913, the influential men of France were willing to meet half way the "Friedensfreunde" of Germany. The writer was present at Nürnberg in 1913, at a great mass meeting in which the Baron D'Estournelles de Constant spoke warmly and eloquently for international friendship. France was becoming ready to forgive if not to forget. But this the Prussian military system in Alsace-Lorraine would not permit. They had left the united province of Elsass-Lothringen without citizens' rights as "*Reichsland*" or Imperial territory, it being an "*Eroberung*" or conquest. They had subjected it to the process of "*Entwelschung*" or deforeignization, by means of trivial and burdensome "*Abwehrgesetze*," or special statutes directed mainly against the use of the French language. The people of Alsace-Lorraine, those of Germanic and French stock alike, could not forget. And for this reason France could not. Had the united provinces been given full autonomy within the German Empire and their people been made full citizens instead of "Deutsche Zweiter Classe," "the nightmare of Europe,"[2] the question of Alsace-Lorraine would long ago have vanished from European politics.

It is a common saying in France, that the Frenchmen of to-day are small because our tall ancestors were killed in our victorious wars.

The statistics behind this statement have been made the basis of a critical study by Professor Vernon L. Kellogg. A synopsis of the results of this study is given in *Social Hygiene,* December, 1914.[3]

[2] "La cauchemar de l'Europe."

[3] It should be clearly noted that a mere decline in stature is in itself of

little racial significance, save as an index in decline in other and more vital regards. Tall stature has been sought for in recruiting armies and so have qualities of boldness and dash. The decline in stature can be measured; the other qualities can not, but we may fairly assume that all soldierly traits have suffered together and the measure of the one serves in some degree as the measure of all.

France has kept for over a century an interesting set of official records which offers most valuable data for the scrutiny of the biologic student of war. They are the records of the physical examination of all the male youths of France as these youths reach their twentieth year of age, and offer themselves, compulsorily, for conscription. To determine who realize the condition of minimum height, weight, chest measurement, and the freedom from infirmity and disease necessary for actual service, all are examined and the results recorded. These records show, therefore, for each year very clearly and precisely the physical status of the new generation of Frenchmen.

The minimum physical condition for actual enlistment has varied much with the varying needs of the nation for men of war. In certain warring periods of her history France has had to drain to the very limit her resources in men able to bear arms. Most notably this condition obtained during the nearly continuous twenty-year period of the Napoleonic Wars.

Louis XIV. in 1701 fixed the minimum height of soldiers at 1,624 mm. But Napoleon reduced it in 1799 to 1,598 mm. (an inch lower) and in 1804 he lowered it two inches further, namely to 1,544 mm. It remained at this figure until the Restoration, when (1818) it was raised by an inch and a quarter, that is, to 1,570 mm. In 1830, at the time of the war with Spain, it was lowered again to 1,540 mm., and finally, in 1832 again raised to 1,560 mm. Napoleon had also to reduce the figure of minimum age.

The death list, both in actual numbers and in percentage of all men called to the colors, during the long and terrible wars of the Revolution and Empire, was enormous. And the actual results in racial modification due to the removal from the breeding population of France of its able-bodied male youth, leaving its feeble-bodied youth and senescent maturity at home to be the fathers of the new generation, is plainly visible in the condition of the conscripts of later years.

From the recruiting statistics, as officially recorded, it may be stated with confidence that the average height of the men of France began notably to decrease with the coming of age in 1813 and on, of the young men born in the years of the Revolutionary Wars (1792–1802), and that it continued to decrease in the following years with the coming of age of youths born during the Wars of the Empire. Soon after the cessation of these terrible man-draining wars, for the maintenance of which a great part of the able-bodied male population of France had been withdrawn from their families and the duties of reproduction, and much of this part actually sacrificed, a new type of boys began to be born, boys that had in them an inheritance of stature that carried them by the time of their coming of age in the late 1830's and 40's to a height an inch greater than that of the earlier generations born in war time. The average height of the annual conscription contingent born during the Napoleonic Wars was about 1,625 mm.; of those born after the war it was about 1,655 mm.

The fluctuation of the height of the young men of France had as obvious result a steady increase and later decrease in the number of conscripts exempted in successive wars from military service because of undersize. Immediately after the Restoration, when the minimum height standard was raised from 1,544 mm. to 1,570 mm., certain French departments were quite unable

to complete the number of men which they ought to furnish as young soldiers of sufficient height and vigor according to proportion of their population.

Running nearly parallel with the fluctuation in number of exemptions for undersize is the fluctuation in number of exemptions for infirmities. These exemptions increased by one third in twenty years. Exemptions for undersize and infirmities together nearly doubled in number. But the lessening again of the figure of exemptions for infirmities was not so easily accomplished as was that of the figure for undersize. The influence of the Napoleonic Wars was felt by the nation, and revealed by its recruiting statistics, for a far longer time in its aspect of producing a racial deterioration as to vigor than in its aspect of producing a lessening stature.

It is sometimes claimed that military selection is of biological advantage to the race as a purifier by fire. This might indeed be true if it were the whole population that was exposed. But it is only a certain part of it that is so exposed, a part chosen on a basis of conditions very pertinent to racial integrity. For in the first place it is composed exclusively of men, its removal thus tending to disturb the sex-equilibrium of the population, and to prevent normal and advantageous sexual selection. Next, these men are all of them of greatest sexual vigor and fecundity. Finally they are all men, none of whom fall below and most of whom exceed a certain desirable standard of physical vigor and freedom from infirmity and disease.

War's selection is exercised on an already selected part of the population. And every death in war means the death of a man physically superior to at least some other man retained in the civil population. For the actual figures of present-day recruitment in the great European states show that of the men gathered by conscription, as in France and Germany, or by voluntary enlistment, as in Great Britain, from 40 to 50 per centum are rejected by the examining boards as unfit for service because of undersize, infirmities, or disease.

Nor is it necessary that these selected men be actually removed by death in order that militarism may effect its deplorable racial hurt. For this removal even for a comparatively short time of a considerable body of these men from the reproductive duties of the population, and their special exposure to injury and disease—disease, we shall see, of a particularly dangerous character to the race—is in itself a factor sufficient to make military selection a real and dangerous thing.

Death in war comes not always nor even most often in battle. It comes more often from disease. And disease, until very recent years, and even now except in the armies of certain few countries, has stricken and still strikes soldiers not only in war time but in the pipingest time of peace. And, what is almost worse for the individual and decidedly so for the race, its stroke is less often death than permanent infirmity. The constant invaliding home of the broken-down men to join the civil population is one of the most serious dysgenic features of militarism.

In the French army in France, Algeria, and Tunis in the thirteen-year period 1872–1884, with a mean annual strength of 413,493 men, the mean annual cases of typhoid were 11,640, or one typhoid case to every 36 soldiers! In the middle of the last century the mortality among the armies on peace footing in France, Prussia, and England was almost exactly 50 per cent. greater than among the civil population. When parts of the armies were serving abroad, especially if in the tropics, the mortality was greatly increased. In 1877 the deaths from phthisis in the British army were two to one in the civil population. And how suggestive this is, when we recall that the examining boards reject all obviously phthisis-tainted men from the recruits. The proportion was still three to two as late as 1884. In the last war of our own

German officials have claimed that military service "provides a special advantage to developing manhood in its compulsory exercise, enforced habits of discipline, unescapable stimulus to patriotism and general moral control." In the words of a German general, quoted by Professor Kellogg,

military service is not injurious to the body, but healthful, not depressing to mind and spirit, but inspiring.

Some of these alleged virtues will not appear as such under other and perhaps more truthful names. But admitting all that may be said, the armies exist for war; their members "especially selected and zealously cared for" are chosen for sacrifice, and the more worthy the sacrifice the greater the permanent loss to the nation. When a man of character and ability, says Professor Kellogg,

gives his life, in war, to his nation, he gives more than himself. He gives the long line, the ever widening wedge of those who should be his descendants. In the long run these may have greater potential value than any political end they have helped to accomplish.

The most economical and most positive factor in human progress is good breeding. Race deterioration comes chiefly from its opposite, bad breeding. Militarism encourages bad breeding.

Despite all delusive phrases to the contrary, the maintenance of an army is a preparation for war and a step toward war and not toward peace. Do governments, or will they, maintain this blessing of military service for the health and eugenic advantage of their people? Is it not done solely from the stimulus of expected war? Is it not done solely with the full expectancy and deliberate intention of offering this particularly selected and cared for part of the population to the exposure of wholesale mutilation and death? This death is to come, if at all, before this extra-rigorous part of the population has taken its part in race propagation, the precise function the performance of which the race most needs from it.

Spain

The Spain of to-day is not the Spain of 1493 to whom the Pope assigned half the seas of the world. Old Spain drooped long ago, exhausted with intolerance, sea power and empire. Now that modern Spain has been deprived of the last vestige of imperial control, she is slowly recuperating on a foundation of industry and economy.

In 1630, the Augustinian friar, La Puente, thus wrote of the fate of Spain:

scientifically enlightened country, the deaths from disease in camp were eight to one from the incidents of battle. But we could do better now. And so could France and England.

In fact, the modern humane war against disease has made life much safer for the soldier. That is to be admitted. But there has occurred so far but one conspicuous radical exception to the general rule of a much greater percentage of deaths from disease than from bullets and bayonets in war time. That, of course, is the record of the Japanese armies in the Russo-Japanese war. The records of the recent war in the Balkan States are like those of a century ago.

Against the credit for redeemed souls I set the cost of armadas and the sacrifice of soldiers and friars sent to the Philippines. And this I count the chief loss; for mines give silver, and forests give timber, but only Spain gives Spaniards, and she may give so many that she may be left desolate, and constrained to bring up strangers' children instead of her own.

Said a Spanish knight:

This is Castile, she makes men and wastes them.

Says Captain Carlos Gilman Calkins:

This sublime and terrible phrase sums up Spanish history.

Says Havelock Ellis:

Everything has happened that could happen to kill out the virile, militant, independent elements of Spanish manhood.[4] War alone, if sufficiently prolonged and severe, suffices to deplete the nation of its most vigorous stocks. "The warlike nation of to-day . . . is the decadent nation of to-morrow." The martial ardor and success of the Spaniards lasted for more than a thousand years. It was only at very great cost that the Romans subdued the Iberians and down to the sixteenth century, the Spaniards were great soldiers. The struggle in the Netherlands wasted their energies and then finally at Rocroy, in the middle of the seventeenth century, the Spanish infantry that had been counted the finest in Europe went down before the French, the military splendor of Spain vanished" ("The Soul of Spain").

It is a question whether Spain suffered most from the scattering of her strong men over seas, from her perpetual struggles in Europe or from the Inquisition. This sinister institution was more wasteful and more cruel in Spain than anywhere else, leading to the extinction of independent minds and of virile intellectuality.

In Spain as in France, the continuance of peace with the cessation of the loss and waste over seas is bringing a financial and industrial recuperation, which must be slowly followed by a physical and moral advance. It is claimed that Spain now enjoys "an intellectual and artistic renaissance that will make her memorable when her heroes are forgotten."

Germany

Germany suffered perhaps scarcely less than France from the wars of Louis XIV. and of the two Napoleons. German writers, however, have been much less frank than the French and also less lucid in discussing their national disabilities. They have given but scanty records of the racial waste their wars have involved. Moreover, the organization of modern Germany, a socialist state under military domination, has tended to minimize the visible distinctions among racial strains. Every man has his place. It is not easy to fall below one's class, correspondingly difficult to rise. Universal compulsory education, technical as well as academic, saves even the feeble from absolute incom-

[4] In this connection, Mr. Ellis extolls the beauty, grace and spirit of the Spanish women and suggests the theory that so far as feminine traits go, there has been no reversal of selection. "The women of Spain," he thinks, "are on the average superior to the men."

petence. The three duties of the citizen, "Soldat sein; Steuer; Mund halten" (be a soldier; pay taxes; hold your tongue), are simple and do not encourage initiative. Universal conscription binds the individual into subjection to the central power. He has the choice between docile acceptance of a fate not wholly intolerable, and revolt with probable misery or death. Forms of insurance against poverty, unemployment or old age guard him against total failure. The difficulties which beset the common man in trying to enter the "learned proletariat" of the universities or the sublimated caste of the army deter all but the most gifted from ambition for advancement. Only real genius for scholarship or for money-getting can break the bonds of caste. This system minimizes the miseries of poverty, while at the same time it checks initiative in the mass of the people.

In general, it subordinates individual freedom to a prearranged discipline of efficiency. This has culminated in the development of the army and navy. To those who regard the dominance of militarism as a survival of savagery, the recrudescence of military ideals in Germany seems one of the saddest results of modern scientific advance.[5]

The victory over France in 1871 has had the effect of intensifying the military spirit of Germany, and of making its extension appear an integral part of the nation's commercial and industrial growth. This fact operates toward final disaster, for whether successful or not in the struggle with the allied powers, the aggregate result will be of the nature of terrible defeat. When the record is summed up it may appear that Germany rather than France is the final sufferer from the Franco-Prussian war and the "blood and iron" policy of Bismarck and his successors.

England

In England, before the Great War, one often heard complaints of the decadence of the nation. This is a habit of the British press in the summer months in the intervals between sensations. The yeomanry were disappearing. The slums of London, Manchester, Liverpool were centers of sweat-shops and child labor, of wasting overwork, of infant mortality, and malnutrition, of sodden drunkenness and helpless old age. And in the higher classes, we were told of "flannelled oafs" and heedless sportsmen, men to whom a cricket match was of more worth than the conservation of empire. Much of this complaint was complacent self-criticism, a favorite amusement with the wealthy unemployed of England. Some of it had the political purpose of discrediting the government, but behind it all rests a certain neglected residuum of truth.

Great Britain has accomplished much in the last century, and much

[5] "To glorify the state is to glorify war, for there is no collective operation which can be so effectively achieved as war, and none which more conspicuously illustrates the sacrifice of the individual to the nation" (Havelock Ellis).

of this has permanent value to the world. She has permeated its thoughts, modified its action and strengthened its character as no other race or nation ever could.

In the Norse mythology, it was the Mitgard serpent which reached around the world, swallowed its own tail and held the world together. England has been the Mitgard-Serpent of history She has made this a British planet. Her young men have gone into all regions where freemen can live. They have built up free institutions held together by the British cement of cooperation and compromise. She has carried her Pax Britannica, the British peace, with its semblance of order and decency, to all barbarous lands, and she has mixed with it enough of freedom to give her rule permanence. She has made it possible for Englishmen to trade and to prey with savages. "What does he know of England, who only England knows?" For the activities of the Greater Britain, of which we of the republic of America form an integral part, are greater by far than those confined to the little island from which the British people set forth to inherit the earth.

What has it all cost? For such great race exertion must take some toll in race exhaustion. This loss will not appear in the decline in ability of statesmen or scholars. It means a decline in their numbers, and the relative increase in numbers of those types of men whom empire can not use.

Much of the force of England has gone out to America and to those self-governing commonwealths no longer to be called colonies, which have spread British traditions over forceful young democracies, who have escaped Britain's greatest evil, the legalization of privilege. But a man is a man, wherever he may live, and we can hardly count the occupation of Canada, Australia, New Zealand and South Africa as loss to the motherland.

But with India the case is not so clear. Men have asked, What has Britain done for India? We may admit that she has done much, and her work, improving with experience, grows more helpful and humane as time goes on. What has India done for Britain? This is a parallel problem little considered, and there is much harm mixed with the good which enters into the calculation. For India has enriched England—a small part of England engaged in overseas trade. The men whom India has made wealthy, men like the Sassoons of the opium trade are not, as a rule, those who share their fortunes with the people, taxed to make these fortunes possible. India has furnished employment for thousands of young Englishmen ("outdoor relief for sons of good families") and it has furnished graves for thousands of British yeomen and British gentlemen, men of spirit whom Britain could ill afford to spare.

A British officer once said to me,

I have seen men who might have been makers of empire die like flies in India.

The methods by which Great Britain, in haphazard fashion, built up her imperial domain have not always been those which conscientious British can defend. They have brought Great Britain into disrepute and they have been used as precedents by rival nations who make no pretense to British scruples. The Great War in Europe has been called the "nemesis of Lord Beaconsfield." Were it not for the imperial chicanery of Lord Beaconsfield's period of unscrupulous glory, the Balkans might never have been fanned into the flames which set all Europe on fire.

England is very rich, if you look at her from above, but her wealth through tradition and through legalization of privilege and abuse is in very few hands. The landholding dukes and the lords of commerce and finance hold the resources of England in their grasp. One fourth the population of Great Britain hold virtually nothing at all. One tenth of them are persistently submerged, and with the waste and havoc of the present war, another tenth will be found to have fallen with them. Says Franklin:

> The profits of no trade can ever be equal to the expense of compelling it by force of armies.

But the profits of the trade obtained through compulsion go to the undeserving few. The cost of compulsion in blood and in gold falls on the body of the nation.

The governments of the world take the risks of imperialism. The great trading, mining, and exploiting corporations receive the gains. In almost every large transaction of any government, there is this constant source of confusion. What the nation expends should be balanced by what the nation receives. It is not enough to estimate "our outgoes" on the one hand and "our receipts" on the other when the outgoes are drains on the public funds, and the receipts are private gains. This fallacy of administration may be found on every hand in connection with almost every item of public expenditure. Public expenditure turned to private gain is the very essence of privilege, and privilege wherever found is the betrayer of justice, the antithesis of democracy. Where privilege exists it violates the principle of equality before the law. In Imperial exploitation a thousand little streams lead from home activities to swell the wealth drawn from overseas.

We admit, says Professor J. Arthur Thomson,

> that wars have been necessary and righteous—especially necessary, and that they may be so still, but this opinion does not affect the fact that prolonged war in which a nation takes part is bound to impoverish the breed, since the character of the breed always depends on the men who are left. The only thing a nation dies of is lack of men and is there not disquieting evidence of the increase of incapables? It is said (in Great Britain) that we can not relax one spine of our national belligerence since we must, at all cost, uphold our national supremacy, having all these teeming millions to feed. But is not this, in part at least, a vicious circle. Is it not preoccupation with militarism that is responsible for keeping up our national misery? With a little money saved off belligerence, what might not be done towards social improvement?

THE PSYCHOLOGY OF WAR

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FROM the flood of writings called out by the war in Europe, a few things have become fairly clear. For instance, it is evident that this is the most costly and the most tragic of all the wars of history, that it has proceeded from the least apparent causes, and that it has come in the face of new and powerful forces making for peace.

But these facts, if such they be, reveal a situation which to the sociologist is more than puzzling, it is amazing. If, as Norman Angell has shown, modern wars are wholly futile so far as the possibility of bringing any kind of gain to the victorious nation is concerned; if war is contrary to the spirit of the age, which is no longer martial, but industrial, commercial and humanitarian; if the contrast between the brutality of war and the culture and refinement of the age is so great that war has become grotesque and anomalous; if the present war is the outgrowth of political rivalries which have largely lost their significance owing to the fact that nearly all present vital human interests have widened out beyond the mere political boundaries of the state and become international in their scope; and if, finally, the nations in order to carry on the war are assuming a debt so crushing that posterity can not exist unless the debt is repudiated in whole or in part, why, then, it would appear that the whole European world has gone insane.

But the student of history and of psychology will look at the matter in quite a different way. He will see that the history of mankind for thousands of years has been a history of incessant warfare and that the new economic and industrial conditions which have made war irrational are not more than about one hundred years old, while the human brain is practically the same old brain of our fathers and forefathers, deeply stamped with ancestral traits and primitive instincts, which can not thus suddenly be outgrown. It is society which has suddenly changed, not the units of society.

Ever since the war began, sociologists, economists, philosophers and political theorists have tried their hands at explaining the causes of the war and with small success. Its roots must be sought in psychology and anthropology.

The anthropologist and historian will review the situation somewhat as follows: The rivalries between nations with their mutual suspicion, distrust and hatred leading to the clash of arms is the survival

of early conflicts between primitive social groups. These conflicts were incessant in all parts of the world wherever there were virile and progressive races and the cause of the conflicts was the natural desire of the stronger to exploit the weaker, it being always easier and more attractive to gain sustenance by robbery than by labor. Furthermore these incessant conflicts were in a high degree beneficial to social development, resulting in the extermination of the unfit and the survival of the strong and the brave. *Within* the primitive groups there was some degree of cooperation, sympathy, mutual helpfulness, regard for life and property, together with some observance of "law" and "order" and "right" and "wrong," this primitive organization resulting perhaps from the rules and regulations imposed by a victorious group upon a conquered group. *Between* the groups there was fear, suspicion, hatred, with no respect for life or property. Might was right. Within the group certain actions were stigmatized as wrong and were punished, such for instance as murder and theft. But between members of hostile groups these acts were praiseworthy.

The modern constitutional state is the historical development of the primitive group. Within the groups, now called nations, the upper classes, nobles, lords, officers, plutocrats, still to a greater or less extent exploit the lower classes, as the victors did the vanquished, and between the groups there is still the old rivalry, suspicion and distrust, while the taking of life and property is still praiseworthy and is not called murder and theft, but war.

But meanwhile within the political state there have grown up two new communities—one moral and the other industrial and commercial, and gradually, while the old bounds of the political state have persisted, the moral and industrial states have expanded till they have burst the bounds of the political state and become international and world wide. A cosmopolitan conscience has replaced the old group conscience and moral obligations extend to all mankind. In time of war between the nations, however, under the transport of patriotism, the old group consciousness revives, with its deep-seated instinct of pugnacity, and with it is revived the old group conscience and the ancient hatred and suspicion, and the ancient desire to exterminate the rival group. Hence the reversion in time of war to primitive standards of conduct.

But under the completely transformed conditions of society in modern times, the original *raison d'être* of war has ceased to be. Victory is no longer to the physically stronger and mentally braver. The vanquished are no longer exterminated or enslaved. The victors lose perhaps as many of their fighters as the vanquished and the disabled are vastly more in number than the dead and both the dead and the disabled are the flower of the nation's youth. Meanwhile, the monstrous cost of a modern war, which impoverishes the nation and its posterity,

the paralysis of a great and intricate system of world commerce and industrial international relations, the colossal destruction of wealth, the irreparable damage to progress and civilization, the impoverished physical heredity of a whole people, the affront to moral ideals slowly and painfully achieved, the untold burden of pain and woe and human suffering in desolated homes far from the field of battle, all combine to make war repulsive and repugnant to modern sense. It no longer cultivates manly virtues but for the most part only machination and mechanical ingenuity.

It is probable that all the benefits which a warring nation hopes to gain by victory are in modern times illusory, or at least they are so far illusory that they are almost if not wholly confined to the circumstances of some hypothetical future war. For instance, a great nation demands the control of some celebrated strait or narrows, so that it may have an outlet for its vast exports—an open way to the sea, although *in time of peace* that nation already has the enjoyment of the freest use of that strait. In other words, were it not for some hypothetical future war, that nation has already the open way to the sea which it demands. Another great nation desires a place in the sun, the freedom of the seas, or a fair share of colonies in distant lands, the colonies being desired for purposes of trade and colonization of its emigrants. But in time of peace this same nation extends its trade by leaps and bounds to every corner of the earth freely and has the utmost freedom of the seas, and sends its emigrants in great numbers to prosperous North and South America. It is only in time of war that the opportunities for trade of that country are limited or that it would profit by having its emigrants under political control. Colonies again in distant parts of the earth may be desired for coaling stations but it is only in time of war that the ships of a nation can not coal freely anywhere.

Still another country desires to retain or regain disputed territory, although in time of peace probably no citizen or group of citizens in its own or in the coveted territory would have its opportunities in any way enlarged or its condition benefited by mere political transference. The acquisition of territory is, again, a common excuse for war, but it has never been shown that, under our modern conditions, the citizens of larger states are any happier or wiser or wealthier than the citizens of smaller states. Thus we have the vicious circle; war exists because of war.

War being thus outgrown and wholly irrational and having no longer any possible purpose except to perpetuate itself, and being opposed to the spirit of the age and discouraged by the powerful peace movements of the day and directly adverse to the all-controlling and all-absorbing industrial and commercial interests of the world, it would seem that it must soon disappear from the face of the earth. But strangely

enough such an outcome, happy as it might be, is made probable neither by the study of history, psychology nor present political tendencies. To the psychologist, indeed, it appears that the whole trend of social movements is in a direction favorable to the perpetuation of war.

One hundred years ago there were bright visions of universal peace. War, it was believed, was an iniquitous invention of evil and mischievous men, interfering with the peace and prosperity of the world. Free trade between nations and free competition between men were to inaugurate a reign of universal peace and prosperity. The function of government was to be limited to a minimum. A sort of universal fraternity, pan-humanism or internationalism was to take the place of fratricidal strife.

This dream has been poorly realized. Free competition has not worked in practise, and the emphasis is being put more and more upon the functions of the state. To be sure many would substitute "society" for the state and, indeed, socialists and Utopianists still look forward to a "new basis of civilization" in which a pleasure economy is to replace the old pain economy, when surplus energy, equality of opportunity, increase of food, short working hours, good sanitation, good housing, etc., will release starving human faculties, resulting in human culture, morality, economic equilibrium and finally in a "denationalized fraternal humanity." Thus with the disappearance of poverty the last obstacle will be removed to upward human progress and universal peace.

It is the purpose of this paper to point out some of the psychological obstacles to the realization of this ideal. Meanwhile it is obvious that the political obstacles are equally great.

At the present time the trend of political events is precisely in the opposite direction. With the unification of Italy in 1859, there awoke the new spirit of nationalism and the revival of patriotism. In 1861, the American Union, fired by the same spirit, resisted disunion. Then followed the unification of Germany, the awakening of the Slavs, the expansion of Great Britain.

Instead of the anticipated free trade between nations, each country by means of protective tariffs drew the mantle of self-sufficiency more closely around itself. In place of the expected pan-humanism a new patriotism has everywhere sprung up. Add to this another fact, perhaps correlated with it, that in the last hundred years a new impulse of cosmic energy, or something of the kind, seems to have flowed into the motor nerves of human beings. There is tremendous activity in the form of striving. The gospel of striving which dates from Lessing and Fichte, and which found its poetic expression in Goethe, is the gospel of modern life. It exhibits itself in intense desire for expansion, for self-expression. It has produced stupendous results in scientific invention, discovery, industrial and commercial expansion. Then fol-

lows the desire for political expansion and the occasion for war is at hand. The gospel of striving inevitably leads to the gospel of strife.

While to a superficial observer the whole tendency of modern thought is in the direction of universal peace, to the more careful observer it is all in the direction of war. It was not even necessary that the voice of Nietzsche with his gospel of the will to power should be reechoed through every land, nor that the new philosophy of Pragmatism should come forward to teach us that nothing succeeds like success.

But perhaps the war in Europe is itself the best witness to the fatal political obstacles which stand in the way of these dreams of peace, for it presents the astonishing spectacle of the greatest war in the world's history proceeding from the least apparent causes and in the face of the most powerful forces working for peace. That such a colossal war should occur under circumstances so adverse to war would seem to indicate that it was made necessary by some tremendous issues, either moral, religious, economic or commercial.

But strangely enough no such issues are apparent. There were no great moral issues involved, as in the American Civil War, no great religious questions as in the crusades and the wars of the Reformation, no great monetary crises, as in some of the Italian and Roman wars. Starvation has sometimes led tribes or nations to war, but starvation threatened none of the present warring countries. On the contrary they were all in a highly prosperous economic condition. Wealth, prosperity, comfort and luxuries abounded. "Never since the world began," says Albert Bushnell Hart, "was trade so broad and profitable as in the year 1913." The total value of international commerce was in that year \$42,000,000,000. The total value of German exports and imports combined was \$5,000,000,000; and of English, \$6,900,000,000. Germany's actual and proportional trade was increasing from year to year. England was exporting goods to Germany valued at \$292,000,000, and importing goods from Germany valued at \$394,000,000 yearly. The entrance of Italy upon the war revealed only too clearly that war has its roots in psychological causes more than in great political or economic issues or in heroic defence of the fatherland.

Does this strange situation admit of any explanation? Or must we say that there are forces at work in social evolution which we do not understand—that it is dangerous for man to meddle too much with his own destiny, and that out of these terrible wars some great good may come in ways unknown? This question may not be answered, but at any rate some light is thrown upon the situation by the psychologist. In all the many books and articles that have recently appeared on the causes of war in general, and the European war in particular, there is a noticeable failure to take due account of the psychological factors in the situation.

As a single typical illustration let us consider the illuminating articles by Mr. G. Lowes Dickinson entitled "The War and the Way Out," published in recent numbers of the *Atlantic Monthly*.

Mr. Dickinson traces the causes of war to the artificial rivalries between those abstract and unreal beings called states, rivalries which are wholly unshared by the real men, women and children who compose the state. The actual citizens of the state desire to live in peace and quiet, to till their land, sell their produce, and buy their necessities, and are but little interested in the question whether the shores of the Baltic shall belong to Russia or Germany or whether Constantinople shall be controlled by one nation or another. Nor indeed do these political relations make any material difference to the people themselves; they make a difference only to that idol, the abstract state, and then only in time of war. The remedy, therefore, is to be found, first, in the cessation of these international rivalries, second, in the international control of armaments, and third, in the elective allegiance of disputed territory, such for instance, as Poland, Alsace and Lorraine. The cause of war being thus removed, the peace-loving, law-abiding and land-tilling citizens will live in happiness and prosperity.

This program is most captivating and no one can doubt that if international rivalries could be prevented in this way, the immediate cause of many wars would be removed. But the greater number of the wars of history have not been between rival states but have been wars of conquest and civil wars and the real causes of them all lie deeper than in any political relations, deeper than the love of conquest, deeper than in any economic or commercial complications. All these alike are the occasions and not the causes of war.

Mr. Dickinson regards the state as an abstraction, in a way unreal, and not having necessarily as its interests the interests of the real people who compose the state. This is true but Mr. Dickinson's constructive program rests, if not upon an abstraction such as the political state, nevertheless upon a myth, namely the myth of the peace-loving, law-abiding and land-tilling citizen, who, if opportunity offers, will till his land and buy and sell his goods in peace and prosperity. This quiet, peace-loving and land-tilling citizen, if not quite a myth, is at any rate not typical of the modern citizen. The typical man of to-day has not, to be sure, any conscious desire for war nor any wish to violate the laws of the state, but he is an exceedingly complex product of biological evolution, of modern civilization and of social forces, and in his own brain may perhaps be found the real powder-magazine responsible for war. The man of to-day is a high-tension being, with a highly organized brain, possessing an immense amount of potential energy in a state of rather unstable equilibrium, the product of an evolution which has discovered the survival value of certain peculiar mental qualities. Beneath this

superior brain, and sometimes perilously near the surface, there lies a vast network of inherited dispositions connecting the man of to-day with his warlike savage ancestors.

In place, then, of this unreal social unit, the peace-loving, land-tilling citizen, we have the real man, the restless and aggressive man, who loves the city rather than the country, frequents the stock exchange, the theater and the moving-picture show, likes to speculate and gamble, is fond of rapid transit by means of steam or trolley car, automobile or aircraft, passes much of his time indoors, reading, writing, planning and contriving, delves into new problems of philosophy, science and invention, exploits new lands and new routes of trade, invents new guns and new explosives, devises new methods of rapid communication and transportation, is addicted to the use of tobacco and alcohol and strong coffee and tea, is subject to chronic fatigue, has a tendency to the use of poisonous drugs and to insanity and suicide and small families.

This is our typical man of to-day and beside him and living in close proximity to him, there is another class, likewise neither peace-loving nor land-tilling, namely, the class of dependents, delinquents, and defectives.

This then is the material we have to work with, and now, given this material, let us suppose that international rivalries should cease, that our colossal modern armies and navies should disappear and that the vast number of men and the enormous amounts of capital involved in military armaments should be turned into productive channels, and let us suppose further that the burden of taxes hitherto required for armies, navies, and pensions should be lifted and with it lifted also the fear of invasion, —what then would happen? Something very different, no doubt, from that condition of idyllic happiness and peace which one infers from the arguments of the pacificists.

The fact is, the causes of war lie much deeper than in any political conditions. They are to be sought in the constitution of the human mind. The question, therefore, is a profoundly difficult one and demands a different method of approach. It must be approached from the biological and psychological as well as the sociological point of view. The following attempt to approach the subject from its psychological side is submitted in the belief that the facts here presented, while no doubt partial and incomplete, are facts which the student of the causes and remedies of war will have to consider.

To understand the psychology of war, it is necessary to go back and trace the actual history of the development of the human being. Here lies the trouble with all our schemes of pacificism and all our Utopias and all our pleasure and peace economies. They deal with an ideal human being, not with actual men. Sociologists will make futile contributions to human progress except as they keep in close touch with the facts of human evolution and of human history.

Some ages ago Nature, as we may say, made a great and wonderful discovery, that of the survival value of intelligence, supplemented later by the discovery of the survival value of sympathy and cooperation. It was no longer, thereafter, a question of tooth and claw, of swift foot, strong arm and warm fur; it was a question of the manufacture and use of weapons and tools and clothes and houses. Psychologically, it was a question of the development of certain new and wonderful mental traits, those of cunning and dexterity, attention and concentration, abstraction, analysis and invention. But these required a large brain, and Nature therefore produced an erect, top-heavy animal, who acquired speech and called himself man. Physically this animal ceased further development. He needed nothing but a large and ever larger brain and a dexterous hand, and, finally, the dexterous hand also was scarcely needed, but brain and brain alone. The brain, however, required nourishment and a certain physical support, hence stomach, heart, lungs, and a circulatory system must needs be retained after some fashion, but the main intent was to develop brain and only brain.

This process is now at its height. Nature we may say is more than ever elated at her discovery of the survival value of intelligence and this discovery is being worked for all that it is worth. There is no limit, it would seem, to the power of the mind. Other animal species are no longer feared. They are not even needed as servants. Electricity can be made to do all things better than the horse. Against intelligence the elements have no longer any power. Storm and lightning and flood are now only interesting episodes. Night is no longer a harbinger of evil but under the glare of the electric light a joy and great delight. Heat and cold are no longer to be considered. Steam and the electric current turn winter into benign summer and night into day. Neither is distance to be reckoned with any more. It is short-circuited by steam, gasoline and electricity.

Especially in continental Europe, in England and America, during the past fifty years, has the march of mind gone forward with dizzy-like rapidity. More than ever has man become master. More than ever are the higher brain centers the only significant organs in the body. Less than ever has Nature found it necessary for her immediate needs to care for stomach, heart and lungs, or muscle and reproductive system. It is mind that counts and mind alone. Nineteenth and twentieth century man has become a high-power efficiency machine combining a marvelous capacity for thought with an unconquerable force of will, but working inevitably under high pressure and dangerous tension.

A gigantic system of wireless telegraphy is not invented and extended over the whole face of the earth in a few years (one might almost say in a few months) without thought and effort. Dreadnoughts and superdreadnoughts, mortars and machine-guns, dirigibles and aeroplanes,

superb and matchless systems of military organization are not perfected without thought and effort. Magnificent cities, fed by a network of smoothly running railroads, are not built without thought and effort. Improved systems of agriculture forcing the earth to produce fourfold more abundantly are not devised without thought and effort. Miraculously wonderful cinematographic machines are not invented without thought and effort, nor without thought and effort is every moving thing from the Arctic to the Antarctic in nature and in art photographed and brought in its living and moving similitude to our eyes. Large continental cities are not freed from graft and brought under elaborately perfect systems of municipal government without thought and effort. Great national and international systems of organized labor are not perfected without thought and effort. The day laborer does not hold himself hour by hour and day by day and month by month to his highly specialized and fatiguing work without thought and effort.

These illustrations could be extended indefinitely. In the work of scientific research, in philosophical study, in industrial and mechanical invention, in the building of great systems of schools and universities, in the management of great commercial and industrial enterprises, in journalism, literature and art, we see exhibitions of ceaseless thought and tireless effort. It is an age of hard work and almost without exception it is mental work of a highly specialized kind and involves stress of the highest and most recently developed brain centers.

It was inevitable that disaster of some kind, or a reaction of some kind, should follow upon this high-tension and one-sided life. Something was bound to snap and something has snapped. Nature has overreached herself in her new discovery of the survival value of intelligence. Intelligence, to be sure, has a survival value of almost limitless degree, but intelligence is, as it happens, linked inseparably to a brain, a highly complex, delicate and unstable mechanism, which was originally intended as a motor center for hand, foot and somatic muscles, and not as a center for thought and sustained effort. Furthermore, the brain itself is organically dependent upon stomach, heart and lungs, whose parallel development Nature in her haste to develop her new discovery has neglected.

The form that the reaction has taken in this case is the form which the psychologist sees it must inevitably take, namely, the temporary reassertion of primitive human impulses. The world has had a thinking spasm of unusual severity; it must have a fling. In America, where conditions were much the same as in Europe, the reaction has taken the milder form of amusement crazes. The dance, the moving-picture show, the automobile, the diamond and the gridiron have helped to relieve the tension. The dancing mania, which has swept over the whole western continent like an obsession, is a good illustration of Nature's

effort to restore the equilibrium of brain centers. Dancing is a pastime as ancient as war itself. It involves none but the very oldest brain paths. It depends upon the very simplest and most primitive form of reaction, carrying us back to the infancy of man and allowing us to revel in the old and racially familiar memories. It affords complete rest and relaxation and tends quickly to establish equilibrium.

To those who do not understand this law of psychological compensation and who have been accustomed to regard the world as getting very serious and civilized and dignified, intent on moral and social improvement, there is something almost as ludicrous in the spectacle of dancing America as there is something pathetic and tragic in that of warring Europe. For in Europe, where the temper of the people lends itself less readily to these lighter forms of release, the reaction has taken the form of a return to most primitive bloodshed. Consequently the war came to us as a distinct shock. One heard everywhere the comment—"It is impossible. I thought we had got far beyond all that." The culture of Germany, France and England was so high that it was unbelievable that these people should suddenly develop hate in its most intense form with a frenzied desire to kill one another. To the psychologist, however, it seems not unreasonable. It is a temporary reversion to completely primitive instincts restoring the balance to an overwrought social brain.

Before the war we heard everywhere of "unrest," a great spiritual unrest. But the significance of this unrest was not understood. It was not due to untoward social or economic conditions, for the world has never seen conditions so favorable for the greatest happiness of the greatest number. Its cause rather was to be found in an asymmetrical development of human personality, too much thought, too much effort, too much "efficiency," and not enough balance, not enough mere somatic vitality. In England this unrest displayed itself as a high degree of social irritability. On the stage it appeared as a carping criticism of social life and social institutions; in literature as a hysterical pursuit of new Utopias; in political life as jarring rumors of civil war.

In Russia just before the outbreak of the war the streets of Petrograd were barricaded by strikers and progressives jealous of real or fancied wrongs. Instantly when war was declared a great inward "peace" settled down upon the warring nations. The restless soul ceased in a moment its feverish upward striving after new inventions, new philosophy, new science and new thought. The brain centers were short-circuited. The social mind sank to the old level. It lived again in the old primitive emotions and the old racially familiar scenes, in pictures of bloodshed and rapine, in memories of the drum-beat and of the tread of marching armies. To be sure there was sorrow and suffering and anxious faces and hunger and hardship and countless woes but these

are old friends to the human mind. The nation was at war but it was at rest. A certain strange harmony settled down upon the people. The war was hardly two months old when we began to hear of a new Russia, a new France, a new England and a new Germany, all regenerated by the baptism of blood, full of high aspirations, purified visions and noble resolutions.

To those acquainted with the psychology of play and sport, war is more easily understood. The high tension of the modern work-a-day life must be periodically relieved by a return to primitive forms of behavior, as in football, baseball, hunting, fishing, horseracing, the circus, the arena, the cock-fight, the prize-fight, and the countless forms of outing. Man must once again use his arms, his legs, his larger muscles, his lower brain centers. He must live again in the open, by the camp-fire, by the stream, in the forest. He must kill something, be it fish or bird or deer, as his ancestors did in times remote. Thereafter come peace and harmony and he is ready once more to return to the life of the intellect and will, to the life of "efficiency."

Periodically, however, man seems to need a deeper plunge into the primeval and this is war. War has always been the release of nations from the tension of progress. Man is a fighting animal; at first from necessity, afterwards from habit. In former centuries when the contrast between peace and war was not so great, it was undertaken with more ease and less apology, almost as a matter of course. Life was less intense then and the reaction of war less extreme. Now in the face of an advanced public sentiment, of peace societies and arbitration boards, the tension has to become very great, the potential very high before the spark is struck and, when this happens, we have the ludicrous spectacle of the warring nations apologizing and explaining to an astonished world.

War, therefore, seems to act as a kind of katharsis. The warring nation is purified by war and thereafter with a spirit chastened and purged enters again upon the upward way to attain still greater heights of progress. In strictness, however, the katharsis figure is misleading. The situation is not one of gross emotions to be purged away, as Aristotle implied. It is rather merely a question of fatigue and rest. Our demand for an ever-increasing efficiency has brought too great a strain upon those cerebral functions associated with the peculiar mental powers upon which efficiency depends. Efficiency demands great powers of attention, concentration, analysis, self-control, inhibition, sustained effort, all of which are extremely fatiguing and demand frequent intervals of rest and relaxation. When this rest and relaxation are lacking, we may always expect cataclysmic reactions which shall restore the balance.

In war, society sinks back to the primitive type, the primitive mortal combat of man with man, the primitive religious conception of God as

God of battles, and the primitive morality of right as might. It brings rest to the higher brain centers, it brings social relaxation, it brings release from the high tension which is the condition of progress. After the war, almost in a day, the nation resumes its accustomed moral standards, just as the debauchee returns to his daily life chastened and subdued.

If the theory of war here suggested is correct, it might be inferred that in modern times, as life becomes more rapid and more strenuous and the brain tension greater, wars would become more and more necessary to relieve the tension and restore equilibrium. It is true that with the heightening of mental life, relaxation of some kind becomes more and more imperative. But with the growth of intelligence the absurdity, futility, and unreason of war as a means of settling disputes becomes more and more evident and with the increase of culture and refinement and of Christian love and sympathy the spectacle of war becomes more and more anomalous and grotesque, so that we have in modern times powerful counteracting forces—forces which are still further augmented by the vigorous humanitarian movements of the times. The motives which make for peace are so great and the absurdity of war so apparent that the fact that wars continue quite as general and quite as frequent as in former times shows that the deep-lying psychological forces which lead to war are more powerful than ever.

In case some way is found to prevent international rivalries, if war between nations is made less and less possible by schemes of international arbitration and conciliation, why, then, it is probable, unless we also discover some method of diminishing the mental tension of our present mode of life, that "unrest," social irritability and probably civil wars will increase. Professor James was wholly right when he hoped for some substitute for war.

The fact is that it does not take a very careful reader of the human mind to see that all the Utopias and all the socialistic schemes are based on a mistaken motion of the nature of this mind.

In fact, it is by no means sure that what man wants is peace, and quiet and tranquility. That is too close to ennui, which is his greatest dread. What man wants is not peace, but a battle. He must pit his force against someone or something. Every language is most rich in synonyms for battle, war, contest, conflict, quarrel, combat, fight. German children play all day long with their toy soldiers. Our sports take the form of contests in football, baseball, and hundreds of others. Prize-fights, dog-fights, cock-fights have pleased in all ages. When Rome for a season was not engaged in real war, Claudius staged a sea-fight for the delectation of an immense concourse, in which 19,000 gladiators were compelled to take a tragic part, so that the ships were broken to pieces and the waters of the lake were red with blood.

You may perhaps recall Professor James's astonishing picture of his visit to a Chautauqua. Here he found modern culture at its best, no poverty, no drunkenness, no zymotic diseases, no crime, no police, only polite and refined and harmless people. Here was a middle-class paradise, kindergarten, and model schools, lectures and classes, and music, bicycling and swimming, and culture and kindness and elysian peace. But at the end of a week, he came out into the real world, and he said,

> Ouf! what a relief! Now for something primordial and savage, even though it were as bad as an Armenian massacre, to set the balance straight again. This order is too tame, this culture too second-rate, this goodness too uninspiring. This human drama, without a villain or a pang; this community so refined that ice-cream soda-water is the utmost offering it can make to the brute animal in man; this city simmering in the tepid lakeside sun; this atrocious harmlessness of all things,—I can not abide with them.

What men want, he says, is something more precipitous, something with more zest in it, with more adventure. Nearly all the Utopias paint the life of the future as a kind of giant Chautauqua, in which every man and woman is at work, all are well fed, satisfied and cultivated. But as man is now constituted he would probably find such a life flat, stale and unprofitable.

Man is not originally a working animal. Civilization has imposed work upon man, and if you work him too hard, he will quit work and go to war. Nietzsche says man wants two things—danger and play. War represents danger.

It follows that all our social Utopias are wrongly conceived. They are all based on a theory of pleasure economy. But history and evolution show that man has come up from the lower animals through a pain economy. He has struggled up—fought his way up through never-ceasing pain and effort and struggle and battle. The Utopias picture a society in which man has ceased to struggle. He works his eight hours a day—everybody works—and he sleeps and enjoys himself the other hours. But man is not a working animal; he is a fighting animal. The Utopias are ideal—but they are not psychological. The citizens for such an ideal social order are lacking. Human beings will not serve.

Our present society tends more and more in its outward form in time of peace toward the Chautauqua plan, but meanwhile striving and passion burn in the brain of the human units, till the time comes when they find this insipid life unendurable. They resort to amusement crazes, to narcotic drugs, to political strife, to epidemics of crime and finally to war. The alcohol question well illustrates the tendencies we are pointing out. Science and hygiene have at last shown beyond all question that alcohol, whether in large or smaller doses, exerts a damaging effect upon both mind and body. It lessens physical and mental efficiency, shortens life and encourages social disorder. In spite of this fact and what is still more amazing, in spite of the colossal effort now

being put forth to suppress by legislative means the traffic in liquor, the per capita consumption of alcoholic drinks in the United States increases from year to year. From a per capita consumption of four gallons in 1850, it has steadily risen to nearly 25 gallons in 1913. The increase in the last two or three years has been less marked, owing no doubt to the remarkable extension of "dry" territory, but this is offset by a great increase in the use of narcotic drugs and of tobacco.

Narcotic drugs, such as alcohol and tobacco, relieve in an artificial way the tension upon the brain by slightly paralyzing temporarily the higher and more recently developed brain centers. The increase in the use of these drugs is therefore both an index of the tension of modern life and at the same time a means of relieving it to some extent. Were the use of these drugs suddenly checked, no student of psychology or of history could doubt that there would be an immediate increase of social irritability, tending to social instability and social upheavals.

Psychology, therefore, forces upon us this conclusion. Neither war nor alcohol can be banished from the world by summary means nor direct suppressions. The mind of man must be made over. War is not social insanity nor is it even social criminality. It is too normal to be classed as either. But war is fast becoming irrational and a substitute for it must be found. Social reconstruction hereafter will have to be conceived on a different plan. It will have to be based on an intimate knowledge of psychology, anthropology and history, rather than merely upon sociology and economics. As the mind of man is constituted, he will never be content to be a mere laborer, a producer and a consumer. He loves adventure, self sacrifice, heroism, relaxation.

These things must somehow be provided. And then there must be a system of education of our young differing widely from our present system. The new education will not look to efficiency merely and ever more efficiency, but to the production of a harmonized and balanced personality. We must cease our worship of American *efficiency* and German *Streberthum* and go back to Aristotle and his teaching of "the mean."

SOME PIONEERS IN MOSQUITO SANITATION AND OTHER MOSQUITO WORK. II.

BY DR. L. O. HOWARD

BUREAU OF ENTOMOLOGY

Dr. Oswaldo Gonçalves Cruz, director of the Instituto Oswaldo Cruz, Rio Janeiro, Brazil. The work of the Oswaldo Cruz Institute in regard to the carriage of disease by insects has been of the highest type. The men are trained in all bacteriological and morphological methods, and their work has placed the institute among the first in the world. Dr. Cruz is responsible for the early and complete elimination of yellow fever from Rio Janeiro and for its reduction throughout Brazil.

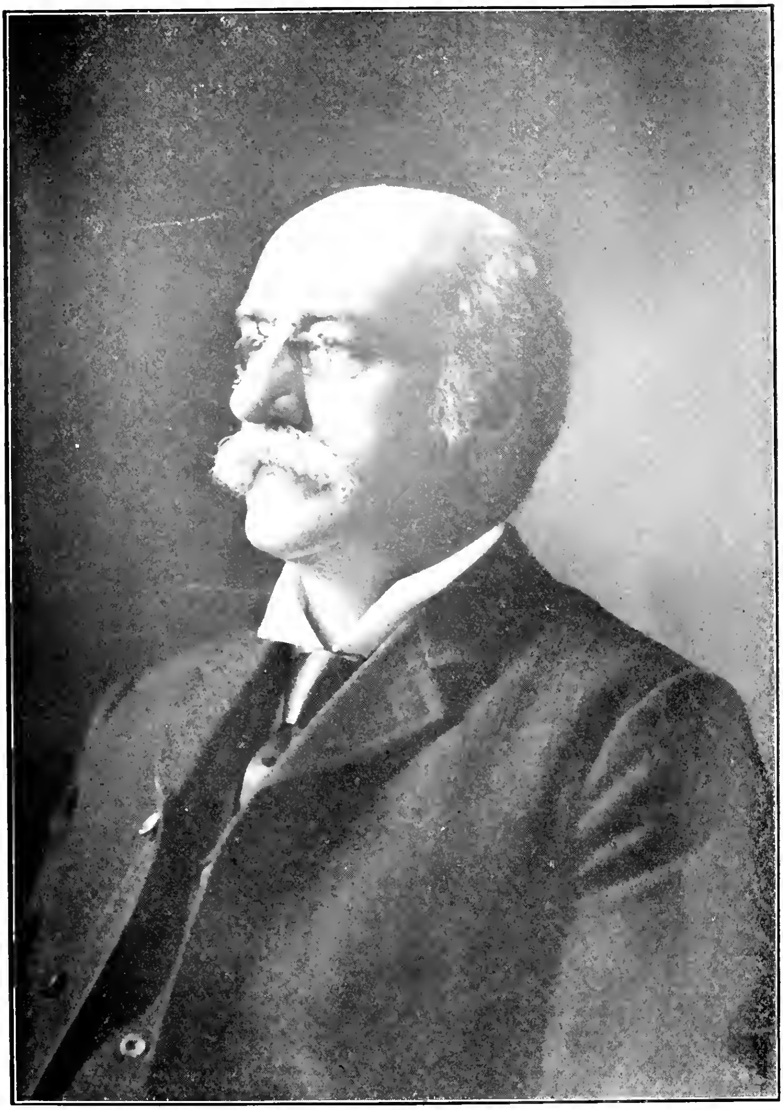
Dr. A. Lutz, chef de service, Oswaldo Cruz Institute, Rio Janeiro, Brazil, formerly director of the Bacteriological Institute, São Paulo, Brazil; well-known worker in helminthology, pathology and bacteriology, as well as entomology; he has done much work on the mosquitoes of Brazil, and has conducted studies of great importance in regard to the relation of insects and disease.

Dr. E. A. Goeldi, professor of zoology in the Cantonal University, Berne, Switzerland, formerly director of the Museum at Para, Brazil, which he founded, and which is known as the Museu Goeldi. He published while in Brazil an elaborate monograph of the mosquitoes of that country, discussing these insects from every point of view.

Dr. Eduardo Liceaga, president of the Superior Board of Health of Mexico; a very enlightened and progressive sanitarian of the highest scientific attainments. He immediately grasped the importance of the malarial and yellow-fever discoveries, and put into effect measures which soon rid the Republic of Mexico of all traces of yellow fever.

Dr. Carlos J. Findlay, president of the Board of Health, Havana, Cuba. Dr. Findlay early announced the carriage of yellow fever by a certain species of mosquito (the same one, in fact, which was definitely proved to be the carrier), but his experiments were not conclusive, and his conclusions were not accepted by the scientific and medical world until nearly twenty years later, when the U. S. Army Commission (Reed, Carroll, Lazear and Agramonte) brought about the overwhelming proof which was generally satisfactory. Findlay's announcement, however, was based on many years' study of the disease and of the mosquito vector.

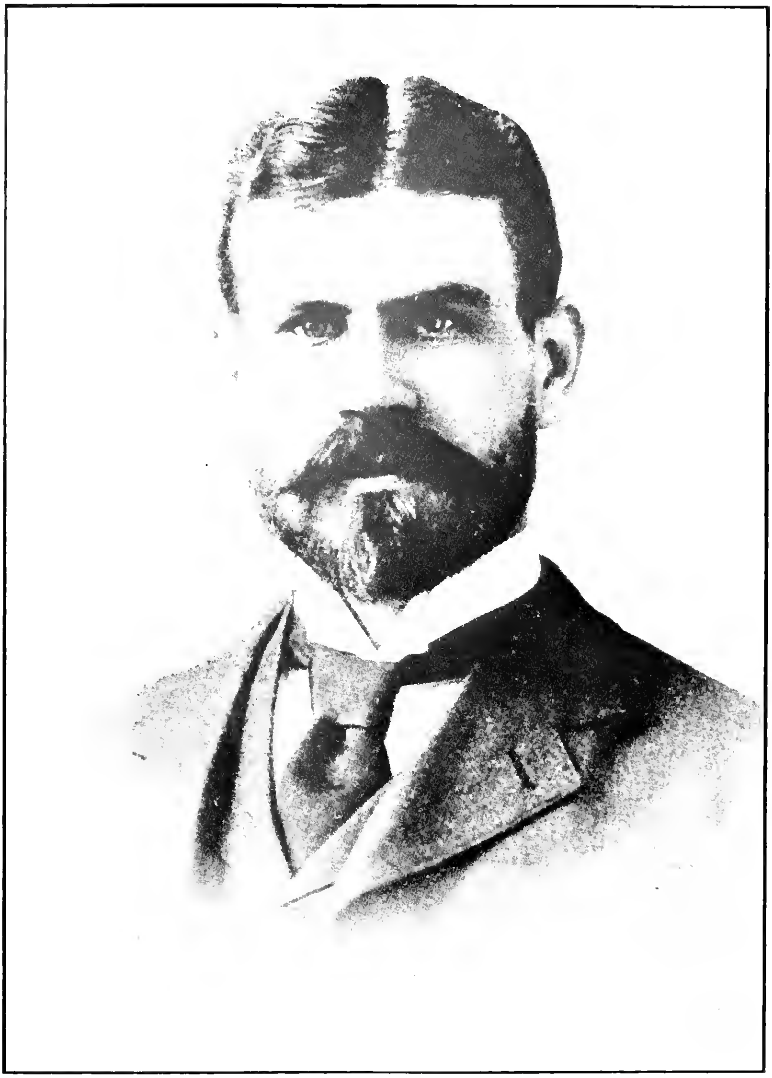
Dr. Aristides Agramonte, Havana, Cuba, professor of bacteriology and experimental pathology, Havana University, Cuba; president of the Board of Infectious Diseases, Cuban Sanitary Department. He was the only Cuban member of the U. S. Army Yellow Fever Commission which proved the transmission of yellow fever by *Aedes calopus* (formerly called *Stegomyia fasciata*) and is the only surviving member of the Commission.



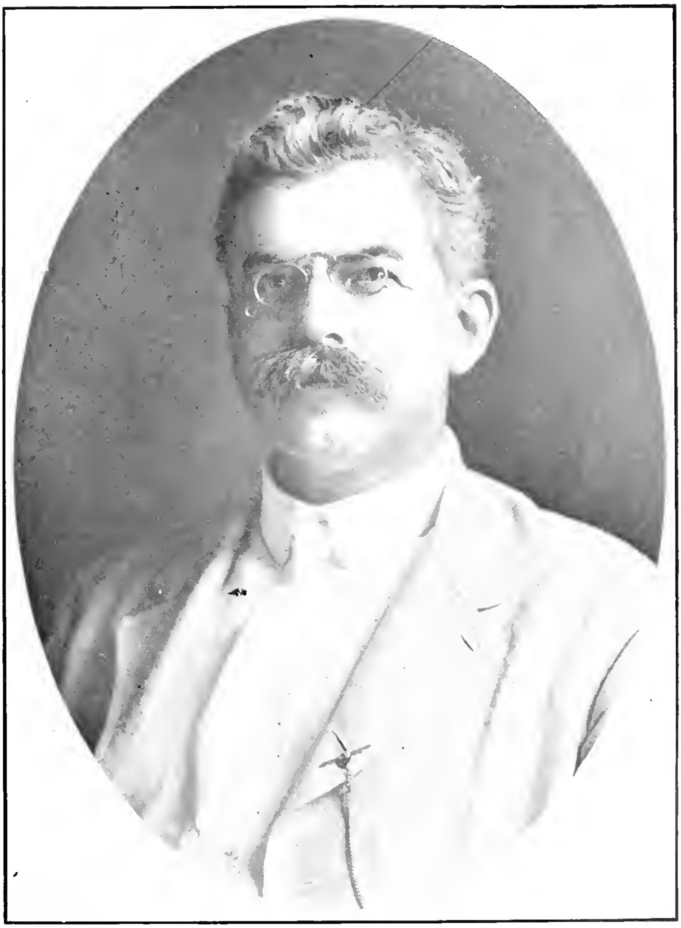
Dr. A. F. A. King. Dr. King was professor of obstetrics in Columbian (now George Washington) University, Washington, D. C., and a well-known Washington physician. He was a man of unusual mentality, and as early as 1883 published in THE POPULAR SCIENCE MONTHLY an extended article in support of the idea that malaria is carried by mosquitoes. His array of reasons was so great and his argument so convincing that his paper has been considered the very strongest of any on the carriage of disease by insects, published prior to the actual proof. He died December 13, 1914, in Washington, D. C.

Dr. Walter Reed, U. S. A., president of the U. S. Army Yellow Fever Commission, he who is to be given the principal credit for the scientific demonstration of the transmission of yellow fever by a mosquito. Dr. Reed died shortly after the complete demonstration was announced, his death being attributable in part to the strenuous work which he had done in connection with these investigations. He was always very loath to have his picture published, and for a long time the only one known was that taken in his early manhood, and which the writer used in an article in the *Century Magazine* of October, 1903. The present picture is evidently from a photograph taken not long before his death, and has been given to the writer by the Army Medical School at the request of Surgeon-General Gorgas.

Dr. James Carroll, U. S. V., member of the U. S. Army Yellow Fever Commission. Dr. Carroll himself had yellow fever in the course of the investigation, as the result of a puncture by the yellow fever mosquito, and died a few years afterwards, his death being attributable in a large measure to the disease and to his hard work during the investigation period.



Dr. Jesse W. Lazear, U. S. V., member of the Yellow Fever Commission. Dr. Lazear was a Johns Hopkins man and died in October, 1900, during the progress of the investigation as the result of a bite of an infected mosquito.



Dr. J. H. White, assistant surgeon general, U. S. Public Health Service. In 1905 Dr. White was given full control by the national, state and city authorities of the yellow-fever epidemic in New Orleans. His work was done strictly on the mosquito basis, and the epidemic, which was fully started and which would certainly otherwise have resulted in thousands of deaths, was wiped out before frost for the first time in the history of yellow fever. The total death list was less than 500.

Dr. W. C. Gorgas, surgeon-general, U. S. Army. General Gorgas (then major) was the chief sanitary officer of Havana, in charge of sanitary work in that city from 1898 to 1902. He immediately grasped the importance of the discoveries of the Army Yellow Fever Commission, and put in operation methods of combating yellow fever, based upon the mosquito idea, which eliminated the disease in Havana. He was made colonel and assistant surgeon general by a special act of congress for this work. He was chief sanitary officer of the Panama Canal Zone from March, 1904, until the completion of the canal, and controlled yellow fever, malaria and other tropical diseases so perfectly as to prove beyond all peradventure the feasibility of an extended occupation of tropical regions by white races.

SOME ECONOMIC FACTORS INFLUENCING THE FORESTRY SITUATION

By A. F. Hawes
STATE FORESTER OF VERMONT

I

IN the movement for the conservation of our natural resources, which is now rapidly gaining strength in our eastern states, as well as in the national government, the influence of many factors must be taken into consideration, and the question may very well arise as to whether our representative form of government, as exemplified in our national congress, our state legislatures, and city councils, is sufficiently far sighted to cope with them. Can these cumbersome bodies, representing, as they do, the contending interests of the day, and having their eyes so closely focused on the present, look into the distant future and pass judiciously on measures affecting the next generation?

It has been a well-recognized policy, on the part of our local governments, to exempt new industries from taxation for a period of years on the ground that such an inducement would counterbalance any advantages that other towns had to offer, and that the new industry would be an unquestioned asset to the community. Very few industries, however, are so constituted that artificial benefits can compete with natural favorable conditions; such as nearness to the supply of raw material, transportation facilities, water power, and a ready supply of efficient labor. Even if these could be counterbalanced, the practise of tax exemption has become so general that it is quite as easy for an industry to secure it in one locality as another, and the result is a practise of community throat-cutting without any appreciable benefits. So long as the practise is tolerated it is, of course, impossible for single towns or cities to prosper without entering into this unfortunate scramble.

A still more important question is as to whether the proposed industries will be really beneficial to the locality in which they are established. They are, as a rule, beneficial or otherwise, according as they have the elements of permanency. That many lines of business of seeming permanency may fail, or after a few years' experience, remove to other places, is, of course, to be expected. So a business, which, by the nature of things, can exist only for a short time, may not be a damage to a community if it leaves that community no poorer than when it came. For example, a corn-canning factory may prosper in a

region just so long as corn production is a profitable line of agriculture for the farmers to pursue. But if some other crop becomes more profitable than corn, the new crop will be raised: or, if the value of dairy products rises proportionately higher than corn, the corn will be used for ensilage.

The removal of such an industry would not impoverish the community except in so far as the local people had invested in it. So a business which exploits without waste a mineral resource, the amount of which can never be increased, can not be considered blameworthy for the entire disappearance of the supply. It is very different when we consider a resource, such as timber, which, by proper handling, can be made permanent, and can be even increased from two to ten fold over its natural productivity. A company which enters a region with the intention of stripping off within ten or twenty years timber which has been one or two hundred years in growing, and which can not be regrown in less than three quarters of a century, is in much the same position as the gentleman swindler who entertains lavishly, pays generously for what he gets, but finally escapes with the wealth of his confiding friends. It is only fair to say that this does not apply to the lumbermen of the past, for, after all, business honesty is a very relative matter, and one can hardly expect a firm to conduct its business on principles in advance of public opinion. That interlocking directorates were in good repute a decade ago will not excuse such a condition in the future.

It will be apparent to any one considering permanent prosperity, that such an industry, removing in a wasteful manner a resource like timber, that could be handled in a better way, is anything but an asset to the community. Such a business not only should not be encouraged by tax rebates, but should be controlled by state regulations safeguarding the community from such disastrous results of a wasteful policy as may be seen in many deforested sections of the country.

Innumerable instances could be cited from various states of serious mistakes in public policy where injurious industries have been encouraged by tax rebates. One may suffice as an example. In a Vermont town there was a timber property that was assessed fifteen or twenty years ago at $40,000. For several years, while this timber was being removed, the saw-mill manufacturing it was exempted from taxation. The mill is now gone, and the real estate is assessed at $1,000. Many other properties have depreciated in the same way, and the inevitable result is a steady increase of the tax rate. Depopulation and degeneration are the natural results of such a policy.

II

Lumber prices in the past have not justified much attention to the growing of timber as a private business. It must be remembered that

these prices have never been based on the cost of growing timber, as are the prices of manufactured articles, upon the cost of production, but have been fixed by competition based simply on the cost of manufacture. While the price of lumber is to-day much higher than it was fifteen or twenty years ago, we must realize that a considerable part of this increase is due to the higher cost of labor, and the increased transportation charges, due to the inaccessible position of much of the timber now being cut. While the stumpage price has also advanced, it has not yet any relationship to the actual cost of growing, but only to the scarcity of, and demand for, the particular kind of timber. Only in the case of a few species, which are in particular demand, and which also happen to be rapid growing, are the prices sufficient as yet to cover the cost of growing. Under this heading may be included such species as the white pine, white ash, basswood and chestnut. On account of the serious disease of the latter it can not at present be advised for growing. Other species, which are almost equally in demand, and which sell for nearly as much, can not be grown for their present sale prices because of their slow rate of growth. As examples of these may be mentioned the hemlock, cedar, birch and maple. The first of these can probably be dispensed with, because its place can well be taken by more rapid growing species; but such species as cedar, birch and maple, which have peculiar qualities of their own, must, if they are to be perpetuated, eventually demand higher prices than the more rapid growing species, in order to compensate the raisers for the greater length of time required. Otherwise, the introduction of some substitute will be essential. Between these two classes is a group of trees whose growth is such that under favorable circumstances they may be profitably raised, but which, under conditions prevailing in many remote sections, can not be grown at a profit. The spruce, balsam, red oak, hickory and poplar may be mentioned in this class.

As the prices for slow-growing timbers must be relatively higher than for rapid-growing species, if they are to persist, so the prices for trees yielding the better grades and wider boards of a species must be considerably higher than for small, poorly developed trees. For some time we have had grading rules formed by various lumber manufacturers' associations for the grading of manufactured lumber, the different grades selling for different prices. This has not generally affected the prices paid for round logs or standing timber. In some localities, where there is a growing competition between wood-working industries for particular kinds of timber, there have been developed, of late, local grading rules for round logs. By these rules, which are similar to those which obtain in European countries, highest prices per unit of volume are paid for large logs free from defects, and the lowest prices for small defective logs with several gradations between. While the prices paid for these

various grades are as yet purely arbitrary, they tend to encourage the holding of the better trees for the higher prices. Eventually these prices must be based on the factors which go to produce these better grades, such as the added length of time, the labor expended in silvicultural operations, etc.

At all conservation meetings the cry is common among lumbermen that prices do not yet warrant the practise of forestry. That this is still true in the remoter regions is indisputable; yet the lumbermen should remember that they have only themselves to blame for the condition, since they have always pushed out into new fields faster than the lumber prices warranted. The public is little concerned whether or not a man can practise forestry profitably in one section of the country, if it is known that he can do so in the more accessible regions. The national production of lumber brings up a very nice question. It is well known among lumbermen that a slight overproduction results in a considerable drop in prices; which is, of course, fatal to the forestry cause. Yet we have the popular demand for cheap lumber and the strenuous opposition on the part of the government to any kind of an agreement among lumbermen to limit the output. In the same way the popular feeling is to-day undoubtedly in favor of no tariff on lumber on the ground that more Canadian lumber will be imported, and that our lumbermen will not be obliged to cut so much. As a matter of fact Germany and other countries, which have paid attention to the growing of timber, have a tariff on lumber to protect their growers from countries like our own, which are wholly exploiters of timber, although at the same time a great amount of lumber is imported by their manufacturers. It should be the duty of some federal commission, possibly the Interstate Trade Commission now under discussion, to try to arrive at a compromise between producers and consumers, whereby the annual output would be sufficiently limited to eliminate waste and maintain prices high enough to warrant the practise of forestry; and, on the other hand, to protect the consumers against monopolistic prices.

III

Bonded indebtedness for railroad construction has been the bane of many a New England town. In the days when the United States government was subsidizing the railroads of the west, the farm towns of New England were raising every possible dollar to build their own railroads in the forlorn hope that in this way they could meet the competition with the fertile lands which a misguided government was giving away in the west. Voting year after year for unneeded protection against foreign nations, these farm peoples were betrayed by the politicians into a far more disastrous competition with cheap lands in the west, which no established community, with accompanying high values,

could resist. The general decline of farm values; migration of the population to cities and the west; the bankruptcy of railroads and similar events, are the chief incidents of the rural history of New England of the last generation. Many of the towns, still overtaxed by reason of long-standing railroad bonds, may well ask the question "whether the railroad was an asset or a liability." In not a few regions railroads were first constructed for the purpose of transporting lumber. If any thought were given to the future it was assumed that agriculture or some unforeseen industry would follow lumbering and would furnish business for the railroad. In many of these sections only a small portion of the soil is adapted for farming, and wood-using industries alone are possible in a community where lumber is the only natural resource. Is it then any wonder that many of these railroads to-day, after the timber has been removed, are on the verge of insolvency? It is too late to remedy this evil in many sections, but new railroads are still being built in the same old spirit of exploitation. Would it not be well for a state, in granting a charter for such a road, to make some provision for the conservation of the natural resources tributary to that road? Such a measure would not only safeguard the community traversed, but would be of inestimable benefit to the innocent stockholders of the railroad, upon whom the road would, sooner or later, be unloaded by the capitalists.

Some form of state control would work no hardship upon the people, if adopted in connection with better transportation facilities. It is a well acknowledged fact that adequate transportation alone makes possible the practise of forestry. Yet, because of the shortness of human life, and the still shorter human judgment, railroads in this country have always resulted in waste and desolation of forests, rather than in conservation and upbuilding, and only in a few cases, where the soil was particularly rich, has forest destruction been justified.

From the standpoint of railroading, there are few crops which furnish the promise for permanent railroad prosperity that is supplied by the timber crop of the well-managed forest. Under fair conditions of soil and management an annual production of 300 board feet per acre is easily obtainable. Let us assume a railroad, fifty miles in length, serving a region about thirty miles wide. If one third of this area is tillable, which is about the average percentage in New England, the total area which should be devoted to forestry would be 640,000 acres. The annual cut from this area would be about 190 million feet of lumber, or 10,000 car-loads, were it all shipped in a rough state.

The average freight rate on a car of lumber from Northern New England to Boston or Springfield, is about $50. Such a traffic would, therefore, be worth to the whole railroad system (although not to this one road alone) a half million dollars a year.

It is estimated there are in New England some twenty-five million

acres better adapted for timber production than for other purposes. If this were all utilized as described above, and one half of the lumber cut were shipped, while the other half was used locally, the railroads would move annually over 200,000 cars of lumber. Is it unreasonable to expect that railroad executives will spend more thought in the future on the conservation of tributary natural resources, and less on the manipulation of funds, than has been the case in the past? The only alternative may have been already foreshadowed by the action of the federal government in undertaking an extensive railroad policy in Alaska for the proper development of the immense resources of that territory.

More, perhaps, than any other class, the forester is concerned with the material prosperity of the future; not, however, from any narrow professional sense, but because of the far-reaching influence of such prosperity upon the development of the future people. He may, therefore, be pardoned for looking at some of these matters from a somewhat different angle from that in which they are usually regarded.

THE WASTE OF LIFE

By ELAINE GOODALE EASTMAN
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To bear a child is nothing; to suckle it, nourish it, bring it to perfection—this is bearing it for all time!—BALZAC.

THE conservation of human life stands next to the giving of life and inseparably one with it as the supreme task of woman. The birth rate is affected by so many different factors that conclusions must not be hastily drawn from any given set of figures. It may be lowered from voluntary or involuntary causes; by extreme want or excessive luxury; by diseases of immorality, or by the higher education of women. It was formerly highest in the centers of population, but this condition is being reversed, and the rural birth rate is falling less rapidly than the urban.

The death rate among young children, however, is actually a touchstone of community welfare; a test of civilization. A high rate of infant mortality means individual ignorance, and social injustice. A lowering of the rate denotes a definite and positive improvement in living conditions, a prevention of economic waste and human suffering comparable only to the total abolition of war in magnitude. The number of babies dying from neglect in the United States alone, would about equal in three years the total number of soldiers killed on both sides during our Civil War!

When we ask how many died in any one year, we find, first of all, our vital statistics greatly modified in value by the surprising fact that effective registration of births and deaths is not yet general throughout this country. From the latest report of the Census Bureau (1911) we learn that birth registration is especially unsatisfactory, and that probably not over one fourth of our population is represented by records even approximately complete. The National Federation of Woman's Clubs is cooperating actively with other organizations and with the Census Bureau itself in the effort to remedy this defect, through the enactment and adequate enforcement of standard laws in the several states. The new Children's Bureau of the Department of Labor, under Miss Julia Lathrop, is bringing additional support to this important movement. It is by no means creditable to us that the accuracy and uniformity of our vital statistics should compare thus unfavorably with those of the civilized nations of the Old World.

The rate of infant mortality has been defined by experts as the ratio of deaths during the first year to the total number of births, and not, as sometimes figured, the ratio of deaths during the first year to the number of living infants under one year of age. For the group of registration states as a whole, the infant death rate calculated under the latter plan was about eight times the death rate at all ages. The death rate of children in the first five years of life was about ten times that of children in the second five years. It is estimated that approximately three hundred thousand babies die annually in the United States before reaching their first birthday. In terms of total population, this means the annihilation of a great city the size of Chicago, or of a state like New Jersey, in a single decade. And at least half of these little lives are needlessly lost. In New York City, in the year 1910, there were 125 deaths under one year for every thousand births; in Washington, D. C., 152; in Lowell, Mass., 231; in Seattle, Washington, only 82! The wide variation is sufficient proof that many, if not most of such deaths are preventable.

Stillbirths have been unaccountably neglected in vital statistics, frequently being counted neither among births nor deaths. In American cities, it has been estimated that 4 per cent. of all babies are born dead, most of them from preventable causes. We do not know the number of miscarriages (also mainly preventable), nor of ante-natal murders, which frequently pass undetected. In France, the number of criminal abortions has been reckoned at fifty thousand to one hundred thousand a year.

Causes of Infant Mortality

It has sometimes been said that the elimination of the feebler children, such as are often exposed to die in savage lands, tends on the whole to the advantage of society. On the other hand, it is important to remember that the causes productive of a high rate of mortality also affect the resistive power of those who survive and sensibly weaken the next generation. Our aim must be to insure that all be well born, and all work for the preservation of the lives of little children helps in the realization of this aim, as will be seen by an analysis of the causes of death. About 10 per cent. of all who die within the year live less than one day, and nearly one third perish before the end of the first month, showing that prominent among the causes of infant mortality is the mother's condition before and during the birth, as affected by alcoholism, social disease and maternal overwork. These same evils tend to produce stillborn and defective children. There is also extended lack of proper care during confinement. In American cities, it is said that about one half of all births are attended by midwives, 90 per cent. of whom are inefficient (Mangold).

The next greatest cause, and one depending partly upon the former,

is the lack of maternal nursing. It has been estimated that as many as 70 per cent. of the infants in New York City are bottle-fed, and therefore have only about one tenth the chance for life of the breast-fed child. Some of these mothers are physically unable to nurse their babies, by reason of ill-health, overwork and under-nourishment; but many more could do so if they sufficiently realized the importance of the service.

A third leading cause, operating, of course, among bottle-fed babies and after weaning, is the use of impure milk. Bad air, flies and all other unhealthful conditions naturally affect the babies more quickly than the adult population; yet experts agree that the health of the mother, her successful nursing of her child for several months, at least, and failing this, a supply of clean, sterile cows' milk, are factors of first importance.

To sum up, we find that from one sixth to one tenth of American babies die before they are one year old, and that more than half of these, perhaps nearly all of them, perish because of maternal ignorance or carelessness, or, more fundamentally, because of unjust social conditions and laws which fail to protect the makers of the new generation. It is full time that the mothers of America were roused to a sense of their grievous, their criminal neglect.

The Mother's First Duty

First of all, there ought to be an active propaganda among women concerning the importance of maternal nursing. Such a movement is needed most in the so-called educated class, since it is estimated that 60 per cent. of well-to-do women employ artificial feeding, and only about 20 per cent. among the poor. The causes underlying the decline of the American family, such as inordinate love of ease and pleasure, the entrance of women into industrial and professional life, and certain diseases of over-civilization, are doubtless responsible for much of this deterioration in the quality of our motherhood. Yet the convenience and attractive appearance of the various widely advertised baby-foods, and the common use of the obnoxious nursing-bottle, have blinded many mothers to the truth, and not a few allow themselves to be persuaded by meddlesome friends or pretty pictures that this is the modern, sanitary way of bringing up children!

Let every young wife be told bluntly that the woman who fails to nurse her child is but half a mother, and that she deprives herself of one of the sweetest pleasures in life, while robbing her little one of its birthright and enormously reducing its chances of survival, and its vigor if it lives. Tell her that artificial feeding is ten times more troublesome and inconvenient than natural feeding; and that the bottle-fed child, though fat and apparently well-nourished, is far more likely

to succumb to infantile diseases, a frequent prey to rickets, and almost certain to be backward in teething, walking and talking. Moreover, a physician of wide experience has said that disuse of the mammary gland has a tendency to manifest itself in the next generation when the baby girl in turn becomes a mother, while the reverse is equally true. Impress upon her the fact that the milk is often slow in coming, and that nearly all mothers can, if they persevere and are in fair health, nurse their babies for at least three months, while a full year is better. Let it be thoroughly understood that bottle-feeding is a grave misfortune if unavoidable and, if avoidable, an unnatural wrong. Let anything and everything which may be found to interfere with this essential function—as social dissipation, overwork and worry, either before or after marriage,—be relinquished in favor of that simplicity of living and wholesome attitude toward life which should restore and preserve a normal American womanhood.

A Shining Example

The progressive little state of New Zealand has for some time boasted the lowest rate of infant mortality in the world. It was reported in 1912 at 51 per 1,000 births, or less than half the (estimated) rate for the United States as a whole. During the years from 1907 to 1912, it is said that the rate in Dunedin, a city of about sixty thousand inhabitants, was reduced 50 per cent. through the activity of a volunteer society called the New Zealand Society for the Health of Women and Children. It is earnestly to be hoped that organizations of women in this country will follow the example and methods of this society, which are described for our benefit in a pamphlet issued by the national Children's Bureau. Taking a few of our oldest cities and states for purposes of comparison, we find that in Connecticut and Massachusetts more than twice as many babies die out of each hundred born; in Rhode Island, three times as many! In the city of Dunedin, during the past year (1913), only 3.8 died in every hundred; in Los Angeles—one of our very best cities—9.7; in Pittsburgh, Pa., 15; in Lowell, Mass., *23!*

The New Zealand society, though a private organization, receives the benefit of government aid and influence. Here, as elsewhere, the cooperation of public and private agencies has proved an effective means of social reform. The main features of the program for public health affecting our subject, are: (1) State registration of nurses; (2) registration of midwives; (3) government maternity hospitals; (4) supervision of infant asylums; (5) complete registration of births.

The society is officered by women and its work is mainly educational. It consists of the instruction of mothers and potential mothers through demonstration lectures, newspaper articles, pamphlets, etc.; the employ-

ment of specially qualified nurses to visit and instruct mothers before and after the birth of their children, and the promotion of needed legislative reforms. It announces itself as

> less concerned with reducing the death rate than with improving the health of the people. However, *the problems are practically identical.*

Work at Home

These and similar methods have been followed to some extent in a few American cities, in part by boards of health, and in part by various private agencies. Already the increase in scientific knowledge, and the new social consciousness, have resulted in a marked reduction in our infant death rate within the last few years. It is estimated that during the decade 1900–1910 the decrease was 19 per cent., or nearly one fifth, which of course satisfactorily offsets, in a measure, the reduction in number of births. The mother's contribution to the world is not to be measured by the number of children she has borne, but by the number brought to a vigorous and useful maturity.

In order to make all the knowledge collected on this subject generally available, to induce comparisons, and to enable one community to profit by another's experience, the Children's Bureau has issued the first of a projected series of annual bulletins on "Baby-Saving Campaigns in American Cities." The lack of financial support is the greatest obstacle to efficient work. The motto of the health department of New York City is worthy of note.

> Public health is purchasable; within natural limitations a community can determine its own death rate.

These significant words should hang upon the walls of every city hall in the land.

Surely nature's first law should be man's first concern, not only for himself, but for the community; not for his own children alone, but for all children, since none can be safe where all are not safe. Legislator, tax-payer, what would you take in exchange for the life of your child? How much are you willing to give in order adequately to safeguard its precious life and all the other precious lives in your community? A certain city of more than a half million inhabitants wrote to the Children's Bureau through its board of health as follows:

> We have *no funds available* to organize a division for the care of infants.

Another large city, on being asked its plans for a summer campaign against children's digestive diseases, replied:

> We have been unable to get an appropriation for a campaign of this kind.

Wherever this state of affairs exists—and may it not be in our own community?—it is incumbent upon individual women to organize, or

through existing organizations to compel public attention to this vital matter. The final responsibility lies with the public, and the outcome of successful private work is usually that sufficient municipal funds are appropriated to take it over. This has been accomplished in Bridgeport, Conn., Milwaukee, Indianapolis, Philadelphia, Baltimore, Richmond, Va., and in many other cities and towns.

While methods vary in different localities, the program for a baby-saving campaign, as outlined by the Bureau, is something like this:

1. Insistence upon complete and prompt birth registration as a basis of work. In some cities, a letter or card is sent each mother upon the birth of a child, thus securing her interest, and with the letter of congratulation a folder may be enclosed, containing advice on the care of infants, and printed, if desirable, in several languages. A strong appeal for breast feeding is always a feature of such advice.

2. Rigid inspection of the milk supply, with frequent tests for fat contents as well as for dirt and bacteria. Recognized grades of wholesome milk include: (*a*) certified milk; (*b*) inspected milk; (*c*) pasteurized milk.

3. The establishment of pure-milk stations, where such milk may be obtained at or below cost, and to mothers unable to pay the price may be furnished free. Such milk must be supplied only on proof of inability to nurse the child, if too young for proper weaning.

4. Baby clinics, and the employment of trained nurses to visit the homes, especially of the very poor, both before and after the birth of a child, to care for sick babies, and to instruct mothers in the care of infants.

5. Improvement of bad housing conditions; the fight against flies and the breeding of flies; and general educational work.

Dr. Josephine Baker, of the New York City Board of Health, has stated that

> babies may be kept under continuous supervision at a cost of sixty cents per month per baby, and the death rate among babies so cared for has been reduced to 1.4 per cent. In other words, the solution of the problem is twenty per cent. pure milk, and eighty per cent. care and training of mothers.

The American Association for Study and Prevention of Infant Mortality owes its existence to the American Academy of Medicine, which called the first conference on that subject ever held in the United States. The association was organized at the close of this meeting, held at Yale University in 1909, and in 1910 an office was opened in Baltimore, from which the work has since been directed. Its functions are chiefly educational, and its work is carried on by general propaganda, by investigations and special work in committees, through an annual meeting and the publication of its transactions, and through a traveling exhibit. Any person interested in the aims of the society may become a member, and the dues are three dollars a year and upward.

Besides the forms of work already mentioned, this association lays stress upon the importance of better teaching of obstetrics in our medical schools, upon the extension of maternity hospitals, out-patient obstetrical services, visiting obstetrical nurses, and either the thorough education or gradual abolition of midwives, also pre-natal instruction of expectant mothers. Many mothers lose their health or their lives, and more babies perish or become permanently crippled or blind, as a result of improper management during child-birth.

Why Poverty is Fundamental

The first field study of the Children's Bureau has just been published (1915), and inaugurates a proposed series of studies in infant mortality, to be made in typical American communities. It was undertaken by means of personal interviews with the mothers of all the babies born in the city of Johnstown, Pa., during one calendar year, 1,551 in all, of whom 196 died, or 134 per 1,000 births. The estimated rate throughout the United States is 124 per 1,000 (U. S. Census Report, 1911), which may be compared with a rate of about 261 in Russia, 105 in England, 75 in Australia, and 51 in New Zealand.

Owing to the method of enquiry, and to the absence of a physician upon the staff of the bureau, only family, social, industrial and civic factors were considered in Johnstown, omitting all reference to two important causes of infant mortality—alcoholism and venereal disease. Emphasis is placed upon the economic factor, and it plainly appears from a study of the tables presented, that, whatever the immediate cause of death, the underlying cause in a large majority of cases was that mother of all evils, poverty.

A study of environment shows that the death rate was 271 per 1,000 babies in the poorest sections of the city, or more than five times that in the best residential sections. It was 171 for foreign mothers as against 104 for native mothers. It was 214 for illiterate foreign mothers, or 66 per 1,000 greater than for foreign mothers who could read. The duration of the mother's rest period before and after confinement was found to affect the result, as was also the employment of a midwife instead of a physician. But most of these points depend directly upon the fundamental question of income. The father's earnings were discovered to be the one factor of greatest importance. Babies whose fathers earned ten dollars a week or less died at the rate of 256 per 1,000, while those whose fathers earned $25 or more a week died at the rate of 86 per 1,000. The foreigners, especially the recent arrivals, were generally those who lived in the poorest and most unsanitary quarters, whose women were ignorant and overworked, forced to carry water, to keep lodgers, or to work for wages, and all these misfortunes were commonly due to the lack of a proper living wage for the men.

Although only 47 per 1,000 died of the babies breast-fed at least three months, as against 166 per 1,000 of the artificially fed, even this advantage was outweighed by the terrible handicap of poverty, as will be at once recognized when we recall that about three times as many of the poorer mothers nurse their babies as of the well-to-do. The death rate among the illegitimate was about twice that of the legitimate, a difference generally recognized as due to almost universal abandonment of such children by the father, and frequent abandonment or neglect by the helpless girl-mother.

The disease directly causing most deaths was found to be bowel trouble or enteritis (usually caused by improper feeding, especially in summer), closely followed by the respiratory diseases (most fatal in winter), and prematurity or congenital weakness, causing death usually within a few days. About 5 per 1,000 were stillborn.

To sum up, although a certain amount of treatment of symptoms may be necessary or desirable, we should bear steadily in mind that whatever tends to modify social inequalities and to give to labor a fair share in the products of labor will do most to save the lives of three hundred thousand babies, yearly offered up in America an innocent sacrifice to the Moloch of selfish greed. And since the whole social body must suffer with the least of its members, is not the idol as short-sighted as he is hideous?

WAR AND THE PROGRESS OF SOCIETY

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WE in America are so accustomed to the idea of social progress, and so familiar with certain actual or so-called progressive ideals, progressive factors and progressive movements, not to speak of progressive parties, that we are likely to assume that progress is general and in the nature of things. Such, however, is not the case. There are no grounds for the prevalent belief in the "general evolution of mankind" in which the nations of Europe, our own country, or any other country for that matter, must necessarily participate in spite of its wickedness, excesses and folly. The very idea of social progress is comparatively new, and the most superficial examination of the facts of social evolution as revealed in history will show that social advancement is sporadic, local and limited in time. Primitive civilizations were as a rule non-progressive. Some of the modern nations, as for instance, China, are practically in a statical condition. National decadence, or the reverse of progress, as for instance in the later history of Spain, Rome, Greece and Egypt, looms large in the background of the past. Extensive regions in the Orient, once the home of advanced civilizations, are now barren deserts from which all life has disappeared. National decadence is in fact a more familiar phenomenon than national progress. As Maine remarks,

> The stationary condition of the human race is the rule, the progressive the exception.[1]

Still, if the doctrine of social evolution be true, and we assume that it is, progress has characterized all peoples at some time in their history. Even in the case of stagnant primitive peoples, as well as the non-progressive nations of to-day, there must have been advancement prior to the time at which they reached their static condition. A brief study of the manner in which this advancement was brought about, particularly the part that war played, and now plays, in the achievement of social progress is the object of this paper.

It is sometimes said, and it seems to be widely believed, that one of the essential factors in social progress is war. This declaration and this belief, however, are unwarranted, as I shall proceed to show.

If we should look into sociological literature to find a specification of the factors of social progress and an accurate analysis of the several circumstances, elements or influences which tend to the promotion of civilization through progress, we should find practical agreement, al-

[1] "Ancient Law," p. 23. See also Bagehot, "Physics and Politics," Ch. I.

though the distinction between factors, forces, means and methods is not always carefully drawn. Buckle, in his "History of Civilization in England" attributes social changes, hence progress, to climate, food, soil and the general aspect of nature. Buckle, however, regards only the external factors of progress; and inasmuch as he holds that physical agents are the primary and the chief factors in human development, he anticipates the modern advocates of the materialistic conception of history. John Fiske says:

> The prime factors in social progress are the community and its environment.

By environment, Fiske means to include not only the climate, soil, flora and fauna, perpendicular elevation, relation to mountain ranges, length of coast-line, character of scenery and geographic position with reference to other countries, but also "the ideas, feelings, experiments and observances of past times, so far as they are preserved by literature, traditions or monuments, as well as foreign contemporary manners and opinions so far as they are known and recorded by the community." He does not attempt to analyze his conception of "community." Professor Carver in compiling his "Hand-Book for Students of Sociology" arranges his material under the following heads: the physical and geological factors, the psychical factors, the social and economic factors and the political and legal factors. In still another classification we find the factors of social evolution divided as follows: physical and geographical, biological, hygienic and eugenic, genetic and economic, political and legal, ethical and religious, esthetic, intellectual and associational.[2]

The literature of the subject aside, however, we need only to glance at the social process to see that the factors at work in the advancement of society are external and internal. The external factors arrange themselves under three heads, namely, the physical, the vital and the societal. The physical factors include soil, climate, topography, etc.; the vital include the regional flora and fauna; and the societal, the surrounding social groups that in one way or another exercise an influence on a given society. The internal factors consist in two things, and two things only: they are men and the things that men have made, or, somewhat less exactly, ideas and the embodied results of ideas in language, literature, the sciences, the arts, law, property, the state, religion, etc. Chief among the internal factors the one indeed from which all others are derived, is the intellect acting as a guide to the will. Professor Ward is practically correct when he declares that it is through the cooperation of the will and the intellect that civilization has been brought about. At all events, these are the great and comprehensive internal factors of civilization and progress.

In presenting these classifications of the factors of social progress, I am not concerned merely with their completeness or accuracy. I wish rather to bring out two significant facts: First, that the factors of prog-

[2] Bogardus, a syllabus entitled "An Introduction to the Social Sciences."

ress are many, and hence in attempting to account for social progress we should be careful not to overestimate the influence of any single factor; and, second, that in none of the foregoing classifications of the factors of progress is there mention of war. Why is war omitted? Is it because in the analyses it has been overlooked? Or is it because it may not properly be included among the factors of progress? Clearly the latter is the explanation. War is not a *factor* of social progress. This will be obvious on considering the real meaning of the term "factor."

If we turn to a definition of the word factor we find it means anything that is employed in the production of a given result. Thus, three is a factor of eighteen. It may be employed in the production of that number, but the manner or method of its employment may be either addition or multiplication. Now it is quite worth while in the interest of clearness of thought on the present subject to make a distinction between the factors that unite or that are employed in the production of a given result, and the manner in which these factors naturally combine or the method by which they are employed in producing that result. Clearly three and six, the factors of eighteen, are quite different from the addition or the multiplication, that is, the method, employed in producing the number. Observe, too, in this connection that while the number of factors that combine or are employed in the production of a given result may be and in general are fixed, the method of employing them is variable. It may be a natural and fortuitous reaction, which is really no method at all, or if consciously employed the methods may be as many and as varied as human ingenuity can devise. With exactly the same factors which by natural reaction or by conscious employment produce a given result, methods of employing them may be accepted or rejected in accordance with our judgment with respect to their effectiveness. We may eliminate what we consider bad methods and employ only what seem to us to be good methods, while the factors may remain the same.

In the case, then, of progress, or its opposite effected by war, the factors are the social groups involved, the war itself being merely the manner in which these factors combine to produce the given result. Is this mode of combining properly to be called a method? That is to say, is war a method of social progress? If war is a method of social progress it is clearly not the only method. Hence it is subject to comparison with other methods as to its relative efficiency. Its value as a method must depend upon its cost and effectiveness as compared with the cost and effectiveness of other conceivable methods of social progress, as for instance education, commerce, contact through travel, and the various other forms of intercommunication by which alone one social group may stimulate the progress of another. If, on comparison, a better method were found, it would show lack of social intelligence not to discard the worse for the better.

But a further consideration will show that war is not really a method of social progress, except in a figurative sense. For method, as De Greef properly observes, is the highest manifestation of knowledge and consciousness;[3] or, as Spencer remarks, the highest self-conscious manifestation of the rational faculty. It implies always and everywhere the perception of an end to be reached, and the conscious selection and employment of the means of reaching it. Before war can properly be regarded as a method of social progress, then, social progress must be conceived as the end to be realized, and war must be entered upon with the conscious intent of thereby promoting social advancement. It is hardly probable, however, that any nation has ever deliberately declared war with the conscious aim of promoting social progress, and it is not likely that any nation ever will do so. Unless and until this is done war, while it may be employed from time to time as a method of attaining governmental, class, or dynastic ends, can not properly be classified as a method of *social* progress.

We have seen then that war is neither a "factor" of progress, nor, properly speaking, a "method" of social advancement. It follows that it is not a "means" of social progress. For a means, strictly speaking, is something chosen for use in the achievement of an end. It implies method. It is that which mediates between the existing condition and the purpose to be achieved. Until some government, nation or society sets up social progress as an aim, and selects war as the agency for bringing it about, it is just as improper to speak of war as a means to social progress as it is to speak of it as a method or a factor of social progress.

So much for what war is not. It is sufficient perhaps to show that what is asserted of war as "an essential factor of progress," an "indispensable method of social advancement," etc., is incorrect, and that the widely prevalent conception of the necessity of war in the promotion of "kultur" and civilization is not well founded—is in fact mere *unsinnige Reden*.

But if war is none of the things already described, what is it? Plainly it can not be argued out of existence. In addition to being a frequent occurrence in the past, it is just now a very conspicuous and stubborn fact. What, then, is its real nature as a social phenomenon? and what is its true relation to progress?

From the social standpoint war is manifestly a form of group interaction. The nations involved have collided while in pursuit of what is regarded as their own individual well-being. War, then, is always entered upon, not with the large and generous object of promoting social progress, but in order to realize one or the other of the narrower and conflicting purposes of social groups. Social progress is not the conscious end, although any of the nations engaged will be ready to identify its own "cause" with progress, and with all that is precious in

[3] See Introduction, "A la Sociologie," p. 441.

civilization. This means that war is a socially unconscious phenomenon. As distinguished from the conscious and concerted, that is to say, artificial, action of society in the promotion of its own well-being, it is a purely natural phenomenon, and socially considered belongs in exactly the same class as earthquakes, floods, famine and pestilence.

To this point we come, then, that war has nothing to do with social progress, except in an incidental way. It is a mode of collective action whose incidental effect may be progress or regress. It is, as De Greef has well said, the best example of a socially unconscious phenomenon. He says:

> La guerre est le phénomenène social inconscient par excellence; la preuve, c'est qu'elle finit toujours par où on aurait dû commencer, si l'on avait été capable d'établir la balance exacte des forces hostiles, c'est-à-dire par des traites.[4]

"But," it will be said, "it can not be denied that war has sometimes resulted in progress." Certainly not; nor can it be denied that it has sometimes resulted in regress. As a result of war states have been founded, and as a result of war states have been destroyed. War has initiated civilizations, and war has overthrown them. And always the effect on social progress has been incidental, unforseen and unintended.

The social effects of war, then, and hence its influence upon progress, are exactly parallel to the effects of the undirected forces of nature. These in their blind action produce results sometimes progressive and sometimes the opposite, but always with absolute disregard of the effects produced and of the amount of energy expended. War, it may be said, belongs to the economy of nature and not to the economy of mind.

Now the common characteristic of the phenomena of nature as distinguished from the phenomena of mind, so far as they are related to the achievement of the ends desired by human beings, is waste. Nature is notoriously prodigal. Progress achieved by it is uncertain, slow and expensive. War, therefore, being from the social viewpoint a natural phenomenon should be expected to exhibit this common characteristic. And so it does. It is perhaps the superlative example of social waste.

Now waste, whether it result from individual or social action, is an evidence of unintelligence. The function of intelligence is to promote economy of time, means and energy in the realization of a given end. Social intelligence, therefore, when it is directed to the promotion of social progress, can not countenance war because of its wastefulness, to say nothing of the uncertainty of its results. Social progress, after the dawn of social intelligence, is really equivalent to the development of such intelligence. The general progress of society must therefore necessarily lead to the social prevention of war. Continuous progress with the continuance of war is a contradiction in terms.

[4] *Op. cit.*, p. 434.

THE FUNCTIONS OF PRIMITIVE RITUALISTIC CEREMONIES

By Dr. CLARK WISSLER
AMERICAN MUSEUM OF NATURAL HISTORY

IF we take a naïve attitude toward primitive ritualism, we must wonder how it ever came about that people believe the proper method for attaining any desired end to be the use of a formula. Thus, we may note a Dakota Indian tossing a handful of dust into the air when going into battle to ensure victory, and wonder how a people, who otherwise impress one as intelligent, could possibly entertain so absurd a belief. Again when we see a primitive doctor singing and demonstrating a ritual over a sick man, we are moved at its pathetic folly. These things are incomprehensible to us chiefly because we can see no reason why the activities involved in the demonstration of a ritual can be considered as directly contributory causes to the ends desired. So long as we confine our attention to isolated cases of ritualism like the preceding our amazement will not abate, but if we examine in detail a large number and variety of primitive rituals, the phenomena become far more intelligible.

One striking feature of primitive ceremonials is the elaboration of ritualistic procedure relating to the food supply. Particularly in aboriginal America we have many curious and often highly complex rituals associated with the cultivation of maize and tobacco. These often impress the student of social phenomena as extremely unusual but still highly suggestive facts, chiefly because the association seems to be between things that are wholly unrelated. Thus among the Pawnee we find an elaborate ritual in which a few ears of maize are raised almost to the status of a god. At a certain fixed time in the autumn the official priest of this ritual proceeds with great ceremony to the field and selects a few ears according to definite standards. These are further consecrated and carefully guarded throughout the winter. At planting time the women present themselves ceremonially to receive the seed, the necessary planting instructions, etc. Thus, it appears that during the whole yearly cycle there is a definite ritual in function associated with maize culture.[1]

Again in the tobacco cultures of the Crow and the Blackfoot Indians, respectively, we find a close parallel. In the former case the ritual is expressed in the organization of a society whose chief function seems to be the direction and control of tobacco production. In the latter, the

[1] The reader wishing a good detailed example of maize rituals should scan the writings of Frank H. Cushing, particularly in volume 9 of "The Millstone."

ritual while no less elaborate is objectively associated with a ceremonial bundle, in which the seed is kept and guarded by the official keeper of the whole. In both cases each important step in the process from seed to pipe is one of the fundamentals in a ritual. Many such examples can be found in the special literature of the subject.

If now we give our attention exclusively to planting rituals certain points of general import may be noted. As a convenient example, we may abstract the following from the data on tobacco culture among the Blackfoot Indians: At the planting of the tobacco seed the leading men hold a feast to which they invite their friends. Eight young men are sent out to gather deer, antelope and mountain-sheep dung. They use this dung because these animals run fast and therefore the tobacco will grow rapidly. They do not use the dung of the elk and moose because the animals walk slowly and would thereby delay the growth of the tobacco. The leading men give a feast which lasts four days, during which they dance and sing. The dung is then mashed up together with service berries, and tobacco leaves and water are added. All these make the tobacco seed ready to plant. The seed is now given out among the planters. To prepare the soil a lot of brush is gathered by all the men, women, and children and spread on the ground. At each of the four corners of this place a fire is started, four men watching the fire so as to prevent it from spreading further. After all the brush has been burnt, they make small brooms of brush with which the place is swept clean. Then a number of men procure sticks with curved roots or having curves that can serve as handles. The straight end of this stick is sharpened and used for digging up the ground. With these sharpened sticks they make holes about a foot apart and two inches deep in a row and the ground is divided up into sections in which each man plants his seeds. The seeds are dropped into these holes, the children covering them up by running back and forth over them four times. Should a child fall while doing this, ill luck would surely follow, and the child will die. After the seeds have been planted incense offerings are made on the four corners of the plot and the songs of the ritual sung.

This part of the tobacco ritual is clearly but a formal expression of the recognized method of planting tobacco. We see that the seed is prepared for germination, the seeds and roots of all intrusive plants killed by burning over the surface, the soil leveled and pulverized, then effectively fertilized and the seed planted in a definite way. What after all is the ritual in this case, but a formalized statement of how tobacco should be planted to secure a good crop?

We also note the existence of specific knowledge of the conditions for tobacco growing, which certainly deserves to be considered scientific. The problem then arises as to how this knowledge came to be associated with a ritual. While we have no direct data as to how the Indian arrived at this knowledge, there is no good ground for believing that it

was developed by the construction of a ritual. So far as can be seen, knowledge that works, even among primitive men, is always arrived at by experimentation. Though it is likely that in this particular case the Blackfoot Indians learned the whole process from strangers, it is certain that each step in the process was originally worked out in some definite locality and the working out of these methods, while in a large measure due to the experience of many, quite likely received its final formalization at the hands of a single individual. This individual was the teacher.

Assuming that this is the condition leading to the formalization of the tobacco-planting procedure, and that it is fundamentally based upon material experiment, how can we account for the seemingly useless ceremonial accompaniments? In the case of culture traits like the tobacco planting of the Blackfoot Indians the problem is always complicated by already existing patterns, or method concepts. Thus it may come to be regarded as axiomatic that to succeed any process must be carried out in a ceremonial manner, or that mere social usage demands that it be so. If either or both of these conceptions prevail, it is clear that the original formalizer of the tobacco planting process would give it a ceremonial dress by introducing into it the more or less conventionalized ceremonial units prevailing in his group. If it was the custom of his people to give some weight to peculiar personal dreams, then also some of his dream experiences might be incorporated. The total construct then resulting would be a tobacco-planting ritual of which the Blackfoot example is typical. Yet this complication need not obscure the essential factor in the case, for, eliminating this "following of existing patterns," we have revealed the backbone of the ritual, the concrete demonstration of processes empirically determined.

Perhaps if we compare the conditions among primitive groups with those under which we ourselves live the case may be clearer. If tobacco planting as a new agricultural trait should be introduced to us, its demonstrator would reduce the necessary directions to writing or cast his oral directions in a form easily reduced to writing. Such writings would then be credited by some authority to furnish the sanctions for the procedure, take certain conventional forms as books, periodicals and lectures, and conform to a certain standards of literary style. Thus we should construct what may be considered a text-book, which, whether written or not, would take the same essential form.

Now, among primitive groups the machinery for perpetuating and standardizing knowledge of this kind is the ritual. The objective method of written records not having been developed, we find in its place a memorized formula whose seriousness and sanction seems to be found in its ceremonial setting. We may safely conclude then that one of the chief functions of a planting or hunting ritual is the perpetuation of the method involved and that whatever may have been the conditions underlying its inception, it grew naturally out of the perpetuation of the

method by instruction. There is no reason to believe that it arose primarily as a ceremonial act, but that it must have been the result of homely experiment.

If we take the widest sort of view of the world there appears no good reason why primitive men should not be considered as great materialists as we fancy ourselves to be. Our anthropological museums are filled with the débris of primitive man's endless experimentation with stone, bone, shell, clay, pigment and metal. In all this one can often trace more or less clearly the successive triumphs of great inventors. Out of this boundless striving, step by step, doubtless hesitatingly and slowly, was built up the world's present store of real knowledge. For ages and ages and even yet, much of it was carried and perpetuated as a mere matter of memory. To distinguish between the essential and the inessential in a procedure is rarely easy, the great human way being to "follow the leader" in every detail, thus naïvely doing the necessary along with the irrelevant. Thus we are able to form a satisfactory theory of ritualism. It is based primarily upon empirical data, for the universal human method has always been "to try it." The experience of all mankind is, that wonders can be worked only by proceeding in certain precise ways, the real reasons for which are often utterly baffling. The person who knows the way can bring the result by merely going through with the formula. It is true even now that many who see the curious workings of these formulæ generalize and conceive of a universal method which is essentially the application of a formula. When such a conception becomes a part of folk-thought, we may expect individuals to experiment and try more or less at random formula of their own devising or, what is more likely, borrowed from another. Thus it comes to pass that many misfit formulæ in use everywhere.

The survival of true misfits in the more material affairs of life is unlikely, but when formulæ are applied to psychological and physiological phenomena, it is very difficult to decide as to their efficacy. A strong corrective influence works in one case in contrast to a weak one in the other. One scarcely need be reminded that our own scientific method developed first in strictly material problems and is but gradually extending its methods to the outlying phases of organic phenomena; and doubtless, here too many naïve and over-generalizing individuals misapply the mere empty methods of material science to the deception of themselves and others.

In short, a ritualistic ceremony in primitive life, and perhaps everywhere, is based upon a methodological ideal of accuracy in procedure or experiment and is an expression of a specific series of procedures so dressed and arranged as to hold the interest, emotions and retentive activities of men. Its primary function is to perpetuate exact knowledge and to secure precision in its application.

JOHN BURROUGHS.

This bust of the naturalist by the sculptor C. S. Pietro has recently been presented to the American Museum of Natural History, New York, by Mr. Henry Ford.

THE PROGRESS OF SCIENCE

THE PACIFIC COAST MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE first meeting of the American Association for the Advancement of Science west of the Rocky Mountains is an event of more than usual importance for science in America. It signifies both the development of a great scientific center on the Pacific Coast and the unity of the scientific interests of the country. It is also the case that the disastrous events in Europe will probably give the United States the leadership in scientific research and in the application of science to the advancement of civilization, and in a sense this new position and responsibility will date from the Pacific Coast meeting of the American Association and its affiliated societies.

It will be remembered that the March issue of THE POPULAR SCIENCE MONTHLY was devoted to the scientific work of the Pacific Coast and at that time there were given accounts of the organization of the Pacific Division of the American Association and of the national meeting to be held this summer in California. It is now needful only to remind readers of these events, and to urge the importance of a large attendance from all parts of the country.

The opening session for the presentation of the addresses of welcome, for announcements and for the presidential address by Dr. W. W. Campbell. director of the Lick Observatory, will be held in San Francisco at 10:00 o'clock, Monday morning, August 2, in the Scottish Rite Auditorium, corner Sutter Street and Van Ness Avenue. The social reception to visitors will occur on Monday evening in the reception rooms of the California Host Building, Exposition Grounds. The general sessions of the association, including three lectures on Pacific region subjects, will be held in San Francisco in the Scottish Rite Auditorium on Tuesday, Thursday and Friday evenings. The sessions of the association and of the affiliated societies on Wednesday, August 4, will be at Stanford University. It is expected that a special train will leave San Francisco at a convenient hour Wednesday morning for Palo Alto and return to San Francisco late in the afternoon. All other sessions of the week will be held at the University of California, in Berkeley.

The general headquarters of the association during convocation week, August 2 to 7, will be in the Hearst Mining Building, on the campus of the University of California, Berkeley. Secondary offices will be maintained: in San Francisco from Saturday noon, July 31, to Friday noon, August 6, in the Palace Hotel; in San Francisco on Monday forenoon, August 2, in the Scottish Rite Building, Sutter Street and Van Ness Avenue; and in Stanford University on Wednesday, August 4. Members will secure badges and programs upon registration. Mail addressed in care of the Hearst Mining Building, University of California, will be delivered as promptly as possible to those who have registered.

Several of the affiliated societies have announced selections of hotel headquarters as follows:

American Astronomical Society and the American Mathematical Society, Hotel Claremont, Berkeley.

American Physical Society, Hotel Claremont, Berkeley.

Geological Society of America, Paleontological Society of America and Seismological Society of America, Hotel Shattuck, Berkeley.

Botanical Society of America, Hotel Carlton, Berkeley.

Zoological Society of America and the Biological Society of the Pacific, Hotel Carlton, Berkeley.

Entomological Society of America, Hotel Claremont, Berkeley.

American Anthropological Association, Hotel Carlton, Berkeley.

American Genetic Society, Hotel Claremont, Berkeley.

American Psychological Association, Hotel Plaza, San Francisco, Post and Stockton Streets.

Archeological Institute of America, Hotel Bellevue, San Francisco, Geary and Taylor Streets.

Round trip special Exposition railway tickets at greatly reduced rates are available from all points to San Francisco, Los Angeles or San Diego as the destination. The price of tickets from points east of the Rocky Mountains is the same whether the destination be San Francisco, Los Angeles or San Diego. The trip going and returning may be by the same route or by different routes, but the routes described on the tickets must be followed. Tickets from Chicago and farther east are valid going or returning via New Orleans. Tickets via Portland, Seattle, etc., involve a supplementary charge, concerning which the local railway representatives should be consulted. The baggage of those who intend to stay in Berkeley should be checked directly to Berkeley, California (by either the Southern Pacific or Santa Fe routes) instead of to San Francisco. All round trip tickets require validation for the return trip.

Railway rates have been greatly reduced, the cost of a round trip being $62.50 from Chicago and $94.30 from New York.

Special lines of steamers advertise passage between the Atlantic and Pacific Coast by way of the Panama Canal at rates varying between $135 and $198 (one way).

Stop-overs for side trips can be arranged either going or returning. Round trip rate from San Francisco to Hawaiian Islands and return by either of several lines of steamers from $110 up. Yellowstone National Park is reached from Livingston on the Northern Pacific (to Gardner and return $3.20). A six-day trip in the park from Gardner costs $40 and another of 5¾ days $53.50. Yellowstone Park may also be reached from Ogden on the Union Pacific by a branch to Yellowstone (round trip $9.25). From here a five-day trip in the park costs $35 and a six-day trip $40.

The Yosemite National Park is reached by Southern Pacific or Santa Fe lines, stopping at Merced, Cal. Round trip from Merced to Valley $18.50. Both hotels and comfortable camps may be found at the camp. Several groves of Big Trees may be visited from the Valley. One grove very much visited is only six miles from Santa Cruz (on the Southern Pacific).

Alaska may be visited by steamer trip from Seattle or Vancouver. Round trip from Seattle $66 and up. From Prince Rupert (on Grank Trunk) a trip to Alaska may be made at an additional expense of about $30.

Attention may be called to two publications which will add to the scientific interest of the trip. The Pacific Coast Committee of the American Association has compiled a guide book entitled "Nature and Science on the Pacific Coast," which contains a large number of articles by leading men of science. The United States Geological Survey has prepared four guide books covering railway routes west of the Mississippi. These books, which contain full descriptions and excellent maps, may be obtained by sending one dollar for each to the Superintendent of Documents, Washington, D. C.

NATIONAL CONTRIBUTIONS TO SCIENCE

Art and religion, like language and customs, may be national, science is by its nature international. Each of the sciences and nearly every branch of

each science consists of contributions made over a long period of time and from widely separated places. One of the evil results in the universal disaster of this mad war is that the orderly progress of science is interrupted. Each week men of science are killed on the field of battle, and young men from whom science must be recruited die by the thousands. The universities of Oxford and of Cambridge boast that each has sent some 8,000 men to the war, and the average life of a British officer after he reaches the front is said to be thirty days. Almost as serious as the sacrifice of men is the loss of the wealth needed for scientific research, and perhaps more disastrous than either is the inevitable distraction of interest and unbalancing of judgment.

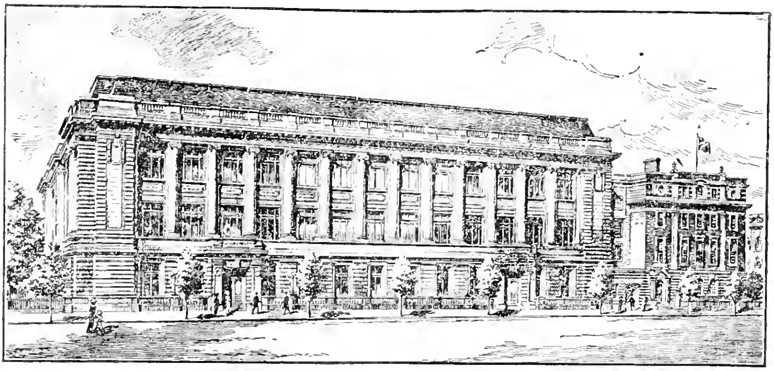
There is a marked disposition at present for the scientific men of England and France to disparage work which has been done in Germany, and conversely. It is consequently pleasant to read a discussion of this subject such as is contributed to a book on "German Culture" (Jacks, 1915) and to *Knowledge* by Professor J. Arthur Thomson of the University of Aberdeen, whose recent article on "Eugenics and War" in this journal will be remembered by its readers. He argues that Britain, France and Germany run neck and neck in their contributions to science, and illustrates this by a series of corresponding names which are here reproduced. It will be noted that the British names are arranged alphabetically and that for each is given a French and German equivalant.

British	French	German
Balfour	Lacaze-	Roux
Dalton	Duthiers	Bunsen
Darwin	Lavoisier	Kepler
Davy	Lamarck	Weber
Faraday	Legendre	Clausius
Fitzgerald	Fourier	Hertz
Foster	Becquerel	Ludwig
Galton	Claude	
	Bernard	Weismann
Graham	Delage	Liebig
Green	Berthelot	Gauss
Hunter	Galois	Gegenbaur
Harvey	Cuvier	Humboldt
Hooker	Bichat	Sachs
Huxley	de Jessieu	Haeckel
Joule	Buffon	Mayer
Jenner	Carnot	Behring
Kelvin	Bordet	Helmholtz
Lankester	Laplace	Johannes
Lister	Giard	Müller
Lodge	Pasteur	Virchow
Maxwell	Ampère	Ohm
Ross	Poincaré	Boltzmann
Burdon-	Laveran	Koch
Sanderson	Brown-	Bois-
Spencer	Séquard	Raymond
Smith, Wm.	Bergson	Lotze
Stokes	Gaudry	Suess
Thomson, J. J.	Lagrange	Cantor
Weldon	Cauchy	Kirchoff
Wright	Quetelet	Zittel
	Richet	Ehrlich

It is easy to criticise any such selection. If we go back to Harvey, Newton should surely be credited to England, and if Kepler is included for Germany, there is no reason why Kant rather than Lotze should not be taken as its representative philosopher. The three contemporary zoologists and the two physiologists credited to England are scarcely among the world's great men of science. But Professor Thomson only claims to use a rough and ready method. His sets of names may be studied to advantage. As he remarks, if we could, as we can not, represent the merits of three counterparts—British, French and German—by the three sides of a triangle, the lengths would now be in favor of Britain, again in favor of France, and again in favor of Germany; yet a superposition of a number of triangles sufficiently large to get rid of conspicuous inequalities would yield a not very irregular figure.

THE NEW SCIENCE MUSEUM IN LONDON

We take from the London *Times* a sketch and some description of the new Science Museum which is to be erected in London between the Natural History Museum and the Imperial College of Science. This building and the one at Munich are the first buildings to be especially constructed for museums of



physical science. The building here shown will occupy about one third of the space, the remainder of which will be left for future extension. When complete the exhibition space will consist of three large roof-lighted halls, 200 by 100 feet, with surrounding galleries on the first and second floors lighted from the sides and from a large central well. It is intended to exhibit the larger and heavier objects, such as locomotives and engines, on the ground floor of the new building.

The museum has a great collection of objects illustrating the history of discovery and invention and the principles of experimental and mechanical science. These include: The earliest steam engines constructed by James Watt for industrial purposes, Stephenson's "Rocket" locomotive, Symington's steam engine, which was the first to propel a boat, and the engine of the "Comet" steamboat. Arkwright's original spinning machinery, Wheatstone's electric telegraph apparatus and other machines and instruments of vast importance contributed by Great Britain to civilization.

Science collections were first arranged in the South Kensington Museum in 1857, but of the early mechanical objects and models the most important are those which were brought together in the Patent Office Museum and handed over to the Department of Science and Arts in 1883. The collection of scientific instruments and apparatus took origin when certain of the objects included in the loan collection of 1876 were deposited in the museum. This collection already includes many illustrations of scientific investigation and inquiry that are of historic interest.

SCIENTIFIC ITEMS

We record with regret the death of Mrs. Matilda Coxe Stevenson, for the last twenty-five years ethnologist in the Bureau of American Ethnology; of Lieut.-Col. Charles E. Woodruff, U. S. A., retired, known for his publications on the effects of sunlight and other subjects; of Dr. Hugo Müller, F.R.S., past-president of the British Chemical Society, and of Sir A. H. Church, F.R.S., formerly professor of chemistry in the Royal Academy of Arts, London.

Amherst College at its recent commencement conferred its doctorate of laws on Professor Benjamin K. Emerson, class of 1865, for forty-five years teacher of geology in Amherst College. Wesleyan University has conferred the same degree on William North Rice, who was graduated from the institution fifty years ago.

Surgeon-General Rupert Blue, of the Public Health Service, was elected president of the American Medical Association at the recent San Francisco meeting.—Dr. Viktor von Lang, emeritus profesor of physics at Vienna, has been elected president of the Vienna Academy of Sciences.—Lord Fisher, former first sea lord of the British admiralty, has been appointed chairman of an "inventions board," which will assist the admiralty in coordinating and encouraging naval science.

THE POPULAR SCIENCE MONTHLY

SEPTEMBER, 1915

THE EVOLUTION OF THE STARS AND THE FORMATION OF THE EARTH[1]

By WILLIAM WALLACE CAMPBELL

DIRECTOR OF THE LICK OBSERVATORY, UNIVERSITY OF CALIFORNIA

Introduction

EVERY serious student of nature asks, sooner or later: What was the origin of the stars? What has been their history? And what does the future hold in store for them?

In harmony with our experience is the belief that all matter in the universe is endowed with the property of obeying certain fundamental laws, such as: every particle of matter attracts every other particle: a hotter body radiates its heat energy to a cooler body; gases expand indefinitely unless resisted by gravitation or other effective force. Again, everything in nature is growing older and changing in condition; slowly or rapidly, depending upon circumstances: the meteorological elements and gravitation are tearing down the high places of the Earth; the eroded materials are transported to the bottoms of valleys, lakes and seas; and these results beget further consequences. In general, the changes in small bodies proceed rapidly and in great bodies slowly.

Astronomers believe there has been an orderly development of the stars, in obedience to precisely the same simple laws that govern our every-day affairs. Starting with the materials as already existing, our problem is to trace in outline the probable course of the evolutionary processes which have given us the stellar universe.

The effort to find a solution brings us against two superlative difficulties:

First, save only the Earth and an occasional meteorite, all the bodies that concern us are at tremendous distances. We must study them at long range, through the reading and interpretation of the messages which their own rays of light and heat carry from them to us. We bring

[1] Second course of lectures on the William Ellery Hale Foundation, National Academy of Sciences, delivered at the meeting of the Academy in the University of Chicago, on December 7 and 8, 1914.

bodies closer, in effect, by means of telescopes, but the reduced distances are still heroic. The stars, some of which are many millions of kilometers in diameter, are still seen as mere points of light in our most powerful telescopes, even though the telescopes magnify 3,000-fold.

Secondly, the evolutionary processes are exceedingly deliberate. We do not know that any *progressive* changes have ever been noted in any celestial body, except in the comets and meteorites, in the Earth's surface strata, and possibly in the so-called new stars. We observe changes in the clouds of Jupiter, changes in the surface features of the Sun, and some 4,000 stars are known to vary in brightness; but all these are short-period changes, and they do not indicate that progressive or permanent changes are involved.

We can get no help in our problem by waiting for any star to show signs of change in physical condition—we should probably have to wait tens of thousands, and perhaps millions, of years. We must take the heavenly bodies as they are, try to fit them into an orderly series representing the various stages of evolutionary development, and justify our arrangement by means of the evidence collected.

We need, first of all, to comprehend as thoroughly as possible what the individual heavenly bodies are, how they are arranged in space, and how they are related to each other, both physically and geometrically. At the cost of telling you many things you have already learned I shall recall a few features in the structure of the solar system and of the stellar system, and describe briefly the characteristics of each class of objects with which we have to deal.

The Solar System.

In the solar system we have the great central body, our Sun, around which revolve the 8 major planets and their 26 moons, the 800 minor planets or asteroids discovered to date, the zodiacal-light materials, the comets and the meteors. The Sun is one of the ordinary stars. It seems very large, very bright and very hot, because it is relatively near to us, and we receive from it our entire supply of energy; but, compared with the thousands of other stars visible on any clear night, it is merely an average star. Nevertheless, the Sun is a very large body; if it were a hollow shell of its present diameter we could pour more than a million Earths into it and still leave empty the space between the earth-balls. Traveling outward from the Sun we come, first, to the small planet Mercury, its diameter a little more than one third the Earth's diameter, which revolves once around the Sun in 88 days; secondly, to the planet Venus, just a shade smaller than the Earth, with period of revolution 225 days; and thirdly, to the Earth and its moon, which revolve around the Sun in one year. Fifty per cent. farther out than the Earth is Mars, its diameter a trifle more than one half the Earth's, with two tiny moons, and period of revolution 1.9 years. Next

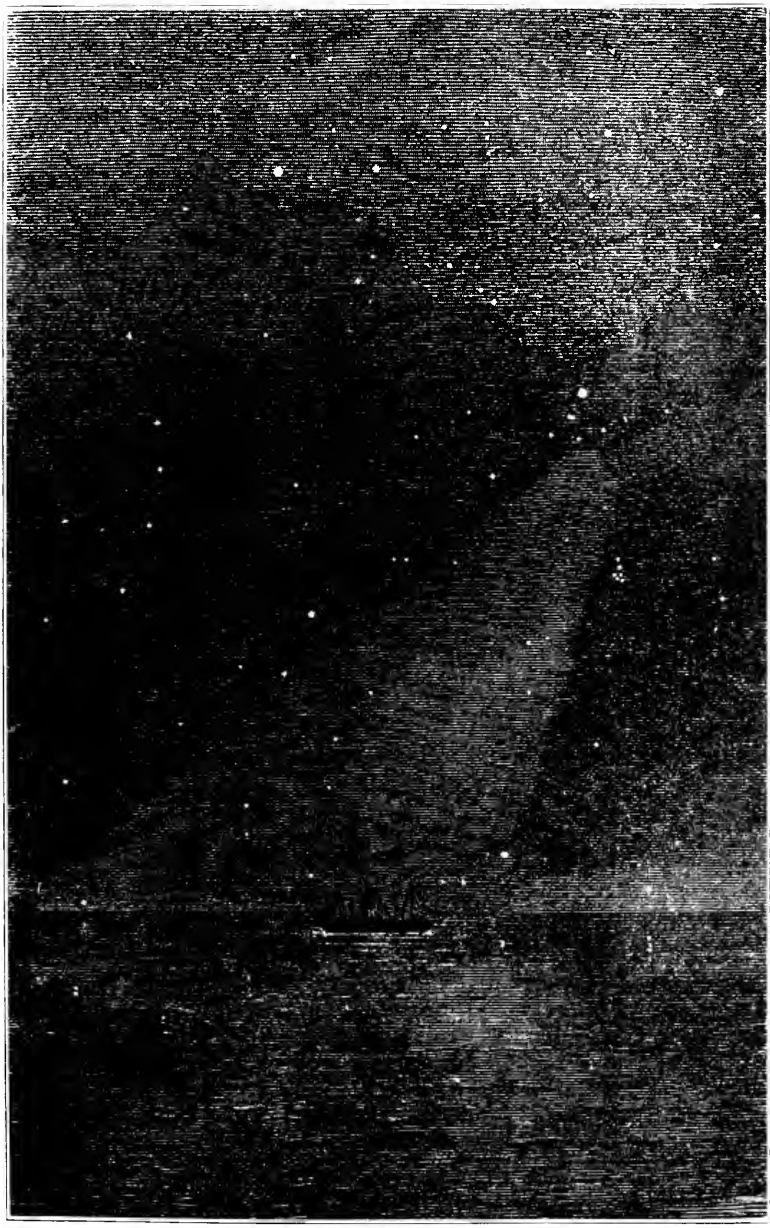


Fig. 1. The Zodiacal Light.

are the asteroids, about 800 discovered to date, which revolve around the Sun, each in its own orbit, in from $1\frac{3}{4}$ to 8 years, the orbits varying greatly in size, eccentricity and position of orbit planes; then we come to the giant Jupiter, its diameter 11 times the Earth's diameter, and 9 moons, the system completing a revolution about the Sun in 12 years; still farther out is Saturn, its diameter 9 times the Earth's, with its wonderful ring system and 9 moons, all revolving around the Sun in $29\frac{1}{2}$ years; next is Uranus, 4 times the Earth in diameter, with 4 moons, all revolving around the Sun once in 84 years; and finally we come to the outermost-known planet, Neptune, a shade larger than Uranus, and its one moon, this planet requiring 165 years to travel around the Sun.

Again, as to the material which composes the solar system: its distribution is most remarkable. Nearly all of it is in the Sun. If we add together the masses of the major planets, the hundreds of asteroids, the satellites, make liberal allowance for the comets, etc., and call the total 1, then the mass of the Sun on the same scale is 744; that is, of 745 parts of matter composing our Solar System, 744 parts are in the Sun and only 1 part is in the bodies revolving around it. To state it differently, $99\frac{6}{7}$ per cent. is in the Sun, and only $\frac{1}{7}$ of 1 per cent. is divided up to make the planets, satellites, asteroids, comets and meteors. The four outer planets, Jupiter, Saturn, Uranus and Neptune contain 225 times as much material as the four inner planets, Mercury, Venus, Earth and Mars. The Earth is fully 3,000 times as massive as the 800 asteroids combined. There is the zodiacal-light material, which, in a more or less finely-divided state, as dust grains or very small bodies, revolves around the Sun, each separate particle in effect a minute planet. This matter, distributed through a great volume of space somewhat the shape of a double-convex lens, whose center coincides with the Sun, and whose edge extends out at least as far as the Earth's orbit, reflects and scatters the Sun's rays falling upon it, and causes the illumination easily visible after sunset in the west and before sunrise in the east. Then there are the comets which pass in orbits usually very elongated around the Sun, their tails pointing approximately away from the Sun; and the meteoric matter, which, at least in part, and quite possibly all, revolves around the Sun in elliptic orbits. Occasionally a meteorite gets through our atmosphere to the Earth's surface, is found and is installed in a museum; but many millions which collide with our atmosphere every 24 hours are consumed by frictional heat in the atmosphere and lose their identity.

It is a most remarkable fact that all the planets revolve in orbits lying nearly in the same plane. Let us call the distance from the Sun to the Earth 1: then the distance from the Sun to Neptune is 30; and the diameter of Neptune's orbit is 60. Now our system lies so nearly in one plane that we could put it in a very flat band-box 60 units in diameter and only 1 unit thick, so that all the major planets and their

satellites, and all the asteroids with a very few exceptions, would perform their motions entirely within the box. The exceptional asteroids and the majority of the comets would dip out of the box because the planes in which their orbits lie make considerable angles with the central plane of the solar system.

It is an equally remarkable fact that the eight planets and the 800 asteroids are all revolving around the Sun in the same direction, which we call west to east. Likewise, the Sun rotates on its axis from west to east, and so also do Mercury, Venus, the Earth and its Moon, Mars, Jupiter and Saturn. Our moon, Mars's two moons, the seven inner moons of Jupiter, Saturn's rings and eight of its moons, revolve around their plants from west to east. From Jupiter out to Neptune we come upon exceptions to the rule. The eighth and ninth moons of Jupiter go around the planet from east to west. The ninth moon of Saturn is similarly reversed in direction. The four moons of Uranus move in a plane making an angle of 98° with the principal plane of the solar system; that is, nearly at right angles to the principal plane. The one moon of Neptune moves in a plane inclined 145° to the plane of the system; in effect, from the east toward the west. The equatorial planes of Uranus and Neptune are, without doubt, essentially coincident with their satellite planes.

The Stellar System.

Our solar system is very completely isolated from other systems. Light travels from our Sun out to Neptune in less than 4½ hours, yet it requires 4½ years to travel from our Sun to the nearest star, α Centauri. Stating the case differently, the nearest star is more than 9,000 times as far from our system as our farthest planet, Neptune, is from the Sun. We should have to go 7 light-years from our Sun in another direction to reach the second-nearest star. It is 9 light-years in a still different direction to Sirius. The average distances between neighboring stars, at least in our part of the universe, is 6 or 7 or 8 light-years. We can see that the stars themselves occupy very little space, and that they have an abundance of room to move about. Recalling, further, that the average speed of the stars is about 26 kilometers per second, which means that about 80,000 years would be required for the average star to travel over the average distance to its neighbor, we can see that collisions of two stars must be exceedingly rare; and that close approaches of two stars, approaches so close as to disturb each other violently, must also be rare. However, when we consider the number of stars in the stellar system, we should perhaps expect a few close approaches to occur in a human life time; possibly also a grazing collision, but probably no full collision.

The universe of stars—our stellar system—is believed by students of the subject, all but unanimously, to occupy a limited volume of space

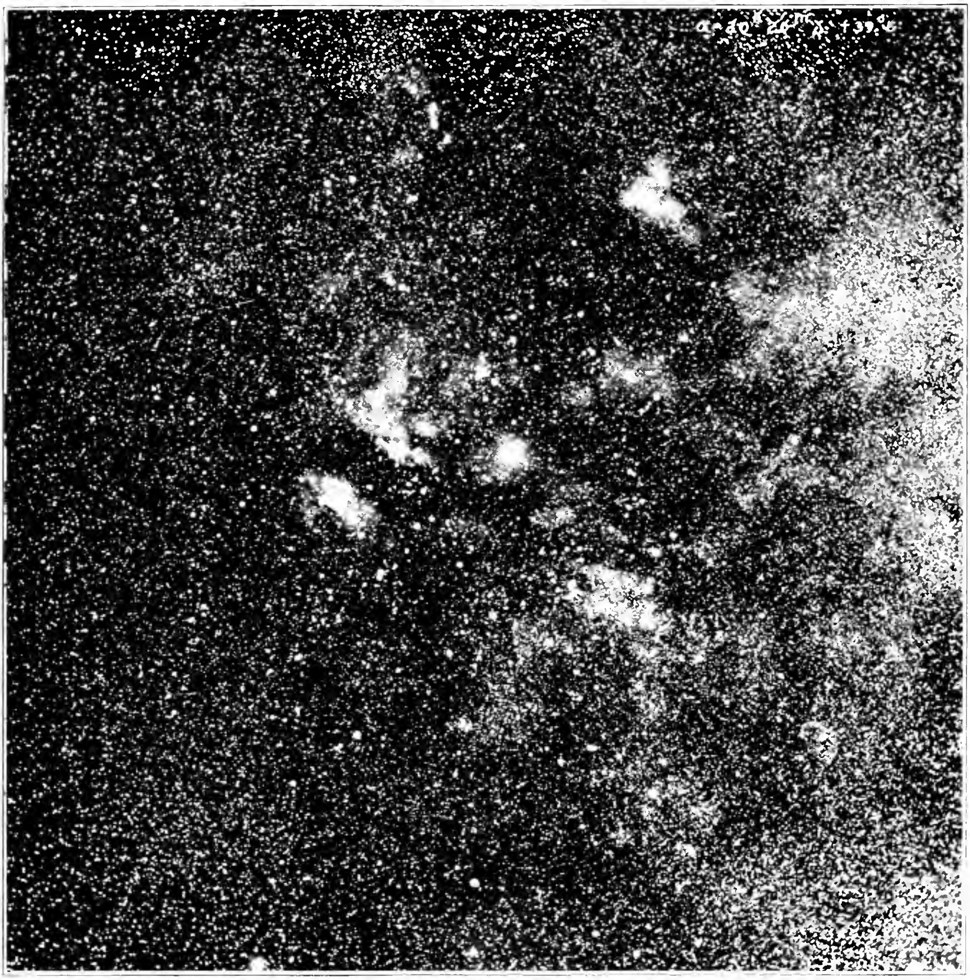


FIG. 2. MILKY WAY IN CONSTELLATION CYGNUS NEAR THE STAR GAMMA, photographed by Professor Barnard with the 10-inch Bruce camera of the Yerkes Observatory.

that is somewhat the shape of a very flat pocket-watch; more strictly, a much flattened ellipsoid or spheroid. However, it is not intended to convey the impression that the boundaries of the stellar system are sharply defined, or that the stars are uniformly distributed throughout the spheroid, and all at once, at the surface of the spheroid, cease to exist; but only that the stars are more or less irregularly distributed throughout a volume of space roughly spheroidal in form, and that the thinning out of stars near the confines of the system may be quite gradual and irregular. The equatorial plane of the spheroid is coincident with the central plane of the Milky Way. We see the Milky Way as a bright band encircling the sky, because in looking toward the Milky Way we are looking out through the greatest depth of stars. There is considerable uncertainty as to the dimensions of the system, chiefly for two reasons: first, the stars near the surface of the spheroid are everywhere too far away to let us measure their distances directly, and, in fact, so far away that we have not been able to measure their transverse motions—their proper motions—and thus to gain indirectly an idea of their distances; and secondly, the spheroid may be considerably larger than it seems because of possible, and even probable, absorption or obstruction of star-light in its passage through space. Newcomb has suggested that the shorter radius of the spheroid, at right angles to the plane of the Milky Way, may be taken as of the order of 3,000 light-years. The long radii of the spheroid, that is, the radii in the plane of the Milky Way, may be at least 10 times as great; that is, 30,000 light-years or more.

The solar system is believed to be somewhere near the center of the stellar system: the counts of stars in all parts of the sky indicate that the Milky Way structure is not much closer to us, so to speak, in one direction than in other directions; there are about as many stars on one side of a plane through the central line of the Milky Way as there are on the other. Wilhelm Struve's statistical studies of stellar distribution led him to conclude that the effective central line of the Milky Way is not a "great circle," but a "small circle," lying at a distance of 92° from the north pole of the galaxy and 88° from the south pole of the galaxy. Interpreted, this means that the solar system lies a short distance north of the central plane of the stellar system.

This conception of the stellar universe and Milky Way agrees in all important particulars with Immanuel Kant's ideas and description published in the year 1755—a remarkable contribution, based essentially on naked-eye observations, without the advantage of accurate observations laboriously made with telescopes. However, it was the star counts by the two Herschels, father and son, which put this conception of the stellar system upon the basis of confidence. Sir William Herschel, using an 18-inch reflecting telescope in the northern hemisphere, and Sir John Herschel, using the same telescope in the southern

hemisphere, counted the stars visible in the eyepiece, 15 minutes of arc in diameter, in 7,300 regions distributed rather uniformly over the entire sky. They found that the number of stars decreased rapidly as they passed from the central plane of the Milky Way toward the north and south poles of the galaxy. Here is a table deduced by Struve from the Herschels' counts.

Galactic Latitude Zones	Average Number of Stars Per Field 15′ in Diameter
+ 90° – + 75°	4.32
+ 75 – + 60	5.42
+ 60 – + 45	8.21
+ 45 – + 30	13.61
+ 30 – + 15	24.09
+ 15 – 0	53.43
0 – — 15	59.06
— 15 – — 30	26.29
— 30 – — 45	13.49
— 45 – — 60	9.08
— 60 – — 75	6.62
— 75 – — 90	6.05

The average number of stars in the Milky Way zone 30° wide, that is, in galactic latitude + 15 to — 15, visible in the eyepiece of the telescope, was 56, whereas in the region surrounding the north and south galactic poles the average number visible in the same eyepiece was but 5. The great condensation in the Milky Way is not fully evident from the table. The stars are much more numerous near the *central line* of the Milky Way than they are near its borders. The average number along the central line, found by Sir William Herschel, was 122. There is no reason to doubt that the preponderance of stars visible in the direction of the Milky Way is due to the greater extension of the stellar system in that direction than in the direction of the galactic poles.

It has been noted by several observers that the faintest stars visible in telescopes of moderate size, that is, stars of the 14th, 15th and 16th magnitudes, are plentiful in the Milky Way and very scarce at a distance from the Milky Way. The contrast between Milky Way and non-Milky Way regions is scarcely noticeable in the naked eye stars, but it becomes stronger and stronger as we pass to the fainter stars.[2]

If there is an absorption of light in its passage through space, such that the very distant stars are appreciably reduced in brightness, then the stars of average size and physical condition must be invisible to us when they are farther away than a certain limiting distance, and in that case the extent of the universe in the direction of the Milky Way

[2] A recent study of Mr. Franklin Adams's excellent photographs of the sky, by Messrs. Chapman and Melotte, shows a considerably smaller disparity in the numbers of faint stars in the galactic and non-galactic regions than the Herschels and others found.

may be vastly greater than we have described it; but this consideration would not act to increase the radius of the actual stellar system in the direction of the poles of the galaxy by any appreciable amount.

Investigations conducted principally at the Harvard and Greenwich Observatories indicate that the number of stars visible in our largest telescopes is of the order of 60,000,000 or 70,000,000, and that the number which can be recorded on photographic plates by means of long exposures with our largest reflecting telescopes is several times as great.

Investigations by Newcomb and Kelvin upon the gravitational power of the stellar universe to produce the observed velocities of the stars give indications that the visible stars contain in reality only a fraction, perhaps one fifth, of the gravitating materials concerned, and they conclude that more material exists in dark and invisible stars than in the visible ones. I am inclined to regard their estimates of dark material as of questionable accuracy, on account of the purely arbitrary assumptions involved.

Stellar Motions

It is necessary that we consider briefly the motions of the stars, including that of our own star. It has been found that all celestial bodies, as far as they have been studied, are in motion with reference to the entire system, and with reference to each other. Our Sun is no exception to the rule: it is traveling rapidly through the stellar system, carrying its planets and their satellites along with it. The apparent motions of the individual stars are not in general their real motions: they are a compound of the real motions and of our motion. If the other stars were really at rest in the great system, they would still seem to be moving because our star is carrying us past them, so to speak: the nearer stars would seem to be moving rapidly, and the more distant stars less rapidly, away from that point in the sky which we are approaching. Since the stars are really moving in a great variety of directions, with a great variety of speeds, their apparent motions are also in a great variety of directions, but the prevailing tendency of their motions is away from our goal.

By studying these compounded motions, Herschel, in 1783, and a long line of distinguished investigators following Herschel, have established that our solar system is traveling toward a point in distant space about on the boundary line between the constellations Hercules and Lyra. If the solar system is moving rapidly toward that point, the stars in that vicinity should, on the average, seem to be approaching us, and the stars in the opposite region of the sky should, on the average, seem to be receding from us. The spectrograph enables us to measure the rates of approach and recession of the individual stars. It has been found that while the hundreds of bright stars in the Hercules-Lyra region are traveling, some away from us and some toward us, with

a very great variety of speeds, yet, on the average, that group of stars seems to be approaching us at the rate of 19 kilometers per second. In a similar manner it has been found that the stars near the opposite point of the sky, while moving individually with a great variety of velocities of approach and recession, are, on the average, receding from the solar system with a speed of 19 kilometers per second. No one questions the explanation of these facts: the solar system is traveling toward the Hercules-Lyra region with a speed of 19 kilometers per second. If, now, the speed of 19 kilometers per second be maintained, and the longer radii of our stellar system be 30,000 light years, we should require a period of 450,000,000 years to travel from the center to the circumference of our system. The youth of the solar system was probably spent in a very different part of the stellar system from where it now is.

Comets

Are the comets bona fide members of the solar system as the planets are, or are they transient visitors from the greater stellar system? Immanuel Kant in 1755 advocated the view that the comets are genuine members of the solar system. From 40 to 70 years later Laplace advocated the other view, that the comets belong to the great stellar system, and that a few of them happen, in the course of their travels, to encounter the solar system. The latter view prevailed from Laplace's time almost up to to-day. If the comets are of our solar system they should move in elliptic orbits; that is, they should return again and again to the vicinity of the Sun.

If the Sun were at rest with reference to the stellar system and the comets should start with exceedingly small velocities from a very great distance, say 20 or more light years away, they would travel around our Sun in curves which we could not distinguish from parabolas. Interpreted, this means that they would eventually go back to approximately the same distant region of space from which they started and never again return to the solar system. If the comets should start toward us, from interstellar space, with appreciable velocities, they would move around the Sun in hyperbolic orbits, curves whose branches, one coming in toward the Sun and one going out from the Sun, diverge widely; such comets would go away to a region of space totally different from that which they had occupied before their solar visits and never return either to us or to their original habitation. Since the Sun is not at rest in the stellar system, but is traveling 19 kilometers per second toward the Lyra-Hercules constellations, it can be shown that the forms of the orbits of comets coming from interstellar space, whether they start from rest or with the average speed of the stars, would, in general, be strongly hyperbolic. The observed facts are that of the more than 400 cometary orbits determined, only 8 or 9 have been suspected to be hyperbolic. Further, the recent researches of Fabry and Ström-

gren have shown that all of the suspected cases either rest upon insufficient observations of the comets at the time of their appearance, so that the orbits are uncertain, or that the disturbing attractions of our planets have converted the orbits from the elliptic to the hyperbolic form after the comets have got well within our planetary system. Another fact is equally important. By virtue of our rapid travels toward the Lyra-Hercules region we should meet more comets coming from that direction than there are comets overtaking us from the opposite direction. To state this point differently: of the comets which swing around the Sun, a greater number should have come into our system from the Lyra-Hercules region than from any other region, and especially from the region of sky which we are leaving behind. The facts are otherwise: we can not say that the approaches of comets favor any particular direction.

The orbits of the great majority of comets are very close to the parabolic form. The nature of comets is such that they are under observation for a few weeks or a few months, and only an occasional one for a year or more. When but a small section of the orbit has been thus observed it is difficult to decide between the parabola and a very elongated ellipse. It happens, however, when these comets have been accurately observed through many months, and the disturbing attractions of our planets have been taken into account, that the orbits are found to be very long ellipses and not parabolas; some of the ellipses are so elongated that thousands, and occasionally hundreds of thousands of years, are required to complete one circuit of the Sun. Let us assume that a comet belonging to the solar system starts at rest, with reference to the solar system, from a point midway between α Centauri and our Sun, and travels around our Sun. It would be 60,000,000 years in reaching us, or 120,000,000 years in completing its circuit. It is evident that an immense amount of cometary material must exist in the outer regions of our Sun's gravitational field in order that a minute part of it may visit the Sun every three months, which is about the average interval of time between the coming of these bodies.

It should be noted that the planes of the very elongated comet orbits show no preference for small angles with the plane of the solar system: they intersect the solar system plane at all angles, and these comets come into our system from all directions indifferently.

We must hold, I think, that the comets are genuine members of our solar system; the great majority spend most of their time in the outer parts of our system, far beyond the orbits of Neptune, but they are moving through space as companions to our Sun as truly as the Earth and Jupiter are.

Aside from the comets which come from great distances, there are, of course, the so-called periodic comets which move in relatively short ellipses, revolving around the Sun in a few years, and reappearing at

predicted times and places. About 60 such comets have been observed with periods less than 100 years. There is the great Jupiter family of comets, about 30 in the family, so-called because their aphelions—the points of the orbits farthest from the Sun—lie near Jupiter's orbit. Their periods vary from 3 to 8 years, their motions around the Sun are all from west to east, as in the case of the planets, and their orbit planes make small angles with the plane of the solar system. In a similar way there are two Saturn comets, three Uranus comets, and six Neptune comets, one of the latter being Halley's. Halley's comet is revolving around the Sun from east to west; that is, in a retrograde direction; and the motions of two comets which disappeared many years ago were likewise from east to west. The motions of all the other short-period comets are from west to east.

The origin of the periodic comets is an interesting question. Newton, of Yale, who was the chief student of the subject, gave practical certainty to the view that the periodic comets have been captured, so to speak, by the major planets, and especially by Jupiter; that is, that comets approaching the Sun in their elongated orbits and passing close to the major planets have had their orbits converted, either during one visit or cumulatively during several visits, into the forms we now observe. Perhaps the strongest doubt as to the sufficiency of the explanation arises from the fact that 95 per cent. of the motions appear to be from west to east. Newton's theory seems to demand that about 25 per cent. of Jupiter's comets should move in retrograde orbits, whereas none of Jupiter's comets, nor the two Saturn comets, do so move. Three of the eleven comets related to Uranus and Neptune, namely, Halley's comet and two lost comets, travel in the retrograde direction. The capture theory is technical and we must not pursue it. Fortunately, there is another avenue of approach. Barnard has noted that the short-period comets differ in appearance from those which come to our system unexpectedly, in that the former are the more diffuse in appearance; that is, they have larger diameters in proportion to their total brightness. There is reason to believe that the head of a comet consists principally of separate small bodies. Now in a collection of small bodies the gravitational forces holding them together are extremely slight. When the group approaches the center of the solar system the Sun's attractions upon the nearer members of the group are appreciably stronger than upon the members which are farthest from the Sun. The orbital motions of the nearer particles are relatively quickened and those of the farther particles relatively delayed. If the comet is traveling upon a very elongated orbit the mutual attractions within the head can again be effective while the comet is in the outer parts of the orbit, and a condensing process probably occurs; but, if the orbit extends out only as far as Jupiter or other major planets, there is little opportunity for the internal attractions to re-condense the particles, and

the next approach to the Sun carries the scattering process a step further. Repeated returns to the Sun dissipate the individual constituents of the comet more widely. The intensity of the comet's light is reduced, and eventually it becomes too faint for discovery and observation. There is little room to doubt that this process is responsible for the total disappearance of several periodic comets.

Meteor Streams

The argument is strongly supported by the meteor streams. It is well known that on certain nights of the year we see an unusually large number of meteors, which come from certain definite directions in space. These meteors have been extensively observed and their orbits have been computed. The illustration shows the orbits of four such swarms.

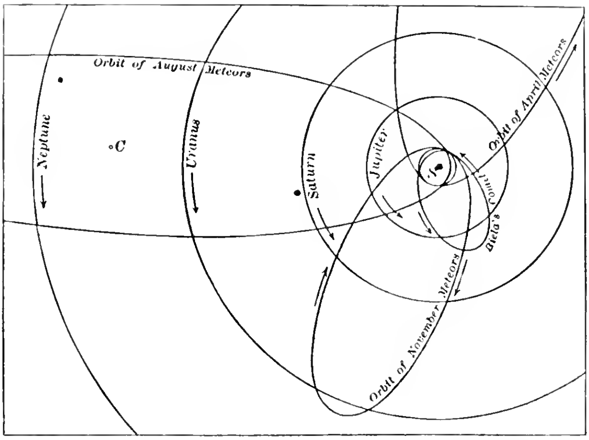


Fig. 3. Orbits of Meteoric Swarms, which are known to be associated with comets.

They intersect the Earth's orbit at certain computed points. We pass through those points on certain nights of the year and the meteoric materials moving in the one orbit collide with the Earth in the other orbit. Now, it has been shown that the orbits of these four meteor streams and of one other stream are the orbits of five periodic comets which have disappeared from sight. Clearly, the cometary materials had been gradually scattered by the disintegrating effect of the Sun's attraction, and the separate particles were compelled to move in orbits differing slightly from each other, and from the recognized orbits of the comets. The meteoric collisions with the Earth are such as to show that we are dealing with widely separated small masses moving in orbits nearly identical with each other.

In the case of these five swarms there is certainly a close connection between meteors and comets. Whether all meteoric matter has come from the disintegration of comets can not be answered now. We can

say that since the Earth actually passes through at least five prominent meteor swarms,[3] there ought to be thousands of invisible swarms within our solar system which we do not pass through. Newton's investigations led him to the conclusion that about 90 per cent. of the meteors which have encountered the Earth and have been observed with sufficient accuracy to let us determine their orbits are moving around the Sun in eccentric orbits of short periods, like those of the short-period comets, and in the west-to-east direction.

The certainty of rapid disintegration of the periodic comets—extremely rapid in comparison with astronomical time-intervals—is all but equivalent to saying that the periodic comets have been recently captured by our planets: for the periodic comets which we are still observing could not have been following their present orbits during many centuries, except at the price of disintegration to the point of total disappearance.

The Zodiacal Light

The zodiacal light is a closely related subject. The phenomenon is due to the presence of countless small particles of solid matter varying perhaps from dust particles up to bodies perhaps many cubic inches or even larger in volume, which scatter the sunlight falling upon them. The volume of space occupied by this finely divided material is very great. It extends north from the Sun to a distance of the order of 100,000,000 kilometers, and there is no reason to doubt an equal southern extension, for observations made in the west after sunset and in the east before sunrise indicate that the structure is symmetrical with respect to the Sun. Its extent in the principal plane of the solar system in all directions from the Sun is even greater. In such clear skies as exist on the tops of mountains the zodiacal light can be seen to stretch entirely across the sky as a faint band following the ecliptic: and this is proof abundant that the materials which scatter the light extend beyond the Earth's orbit.

Inasmuch as we do not distinguish the individual particles which make up the zodiacal light materials, we can not now say whether they are revolving around the Sun from west to east, but we can not doubt the fact that they are revolving around the Sun and that the orbits of a large proportion of the particles are necessarily in planes highly inclined to the general plane of the solar system. Seeliger is of the opinion that this material supplies the attracting mass which disturbs the motion of Mercury, and to a lesser degree the motions of Venus, Earth and Mars. If this be true the total mass of the particles must approximate to that of the planet Mercury.

Where this material came from, whether it is a remnant of the original material which formed the inner planets and the Sun, or whether it has come in from the outer confines of the Sun's sphere of

[3] Numerous minor streams are reported by meteor observers.

influence in the same way that the comets have transported very distant materials into the terrestrial region, is wholly unknown.

Stars Clusters

The star clusters offer a wide range of character, as to their density of stellar contents and as to the symmetry of distribution. There are the large irregular clusters visible to the eye, such as the Pleiades, Praesepe, the Perseus clusters, in which the stars are widely separated and irregularly distributed. There are the globular clusters, invisible to the naked eye, except in three or four cases, which contain multitudes of faint stars densely crowded together and quite symmetrically arranged. The great cluster in Hercules is the most striking example in the northern skies. The accompanying photograph, secured with the 60-inch reflector of the Mount Wilson Observatory, records stars to the order of 30,000, each star a sun as truly as is our star. There are two still more extensive clusters in the Southern Hemisphere, but they have not yet been photographed on the same scale as the northern clusters. The globular clusters, of various degrees of stellar richness, exist to the number of several scores.

There are two great agglomerations of stars—two dense clouds of stars—occupying isolated positions in the far southern sky, quite distant from the Milky Way, which seem to have many of the Milky Way's attributes. They appear to be great irregular clusters of stars differing only in size from the vastly greater Milky Way cluster. These objects are known as the Greater and Lesser Magellanic Clouds.

The Nebulae

The objects which probably concern our subject most directly are the nebulae. The word nebula means a "little cloud"; and like little clouds superimposed upon the dark background of the sky the first 10,000 nebulae looked to their discoverers. They were of various sizes, from that of the Orion nebula, and even larger, down to those indistinguishable in small telescopes from stars, and to those so faint as to be on the limit of telescopic vision. The Herschels, father and son, were the first great discoverers of the nebulæ. Lord Ross's reflecting telescope showed that a few of the very bright and large nebulæ, perhaps two dozen in all, are not formless masses, but spirals—indicating plainly that they have motions of rotation. It was noticed by Sir William Herschel, a century ago, that the distribution of the nebulæ on the surface of the sky is most remarkable. Proctor's chart, published in 1869, illustrates this fact. On this chart the cloud-like forms of the Milky Way are outlined across both hemispheres, as seen by the naked eye, but it should be said that telescopic vision of the Milky Way would present very different and vastly more uniform outlines. Each dot on the chart represents a nebula. He who runs may

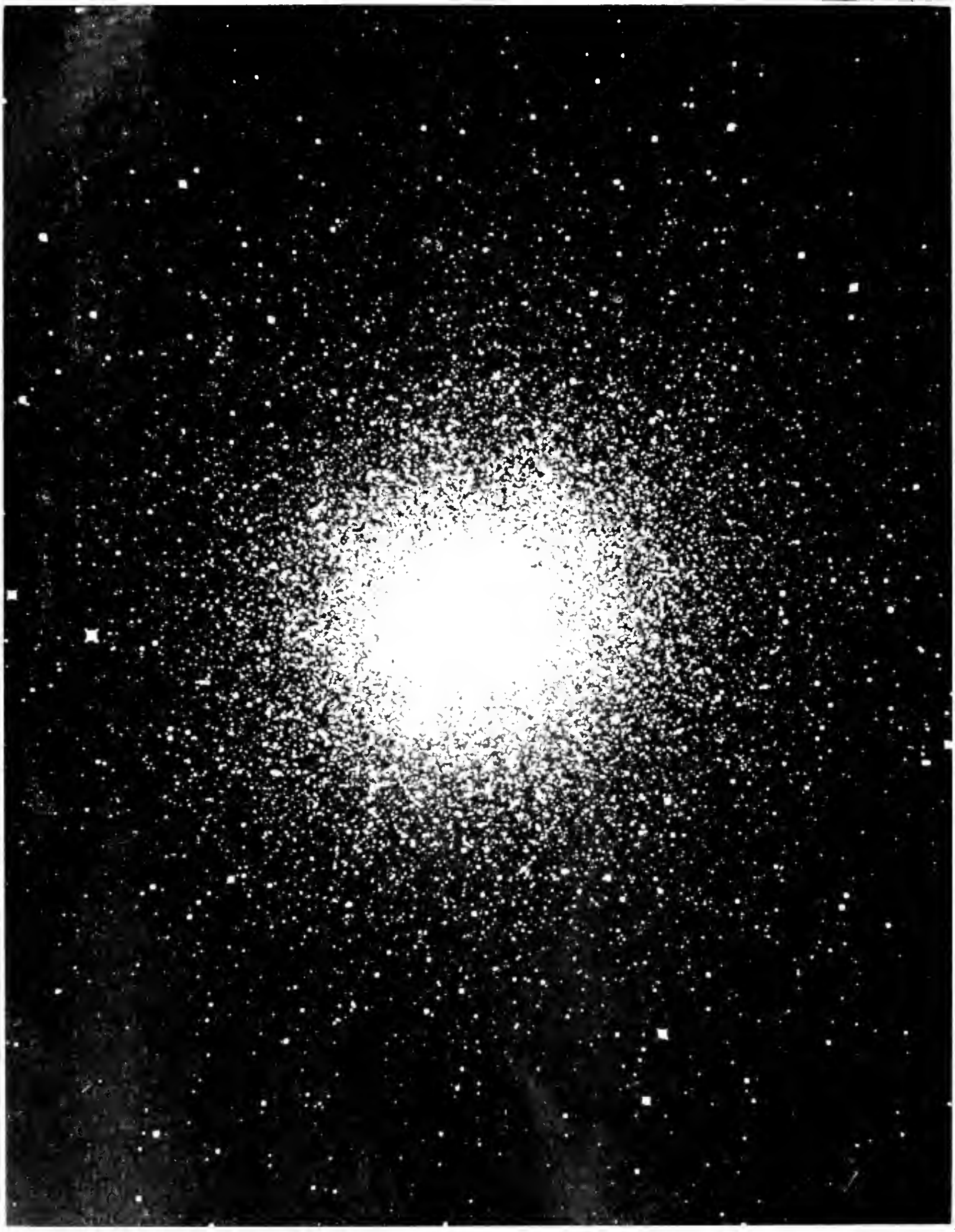
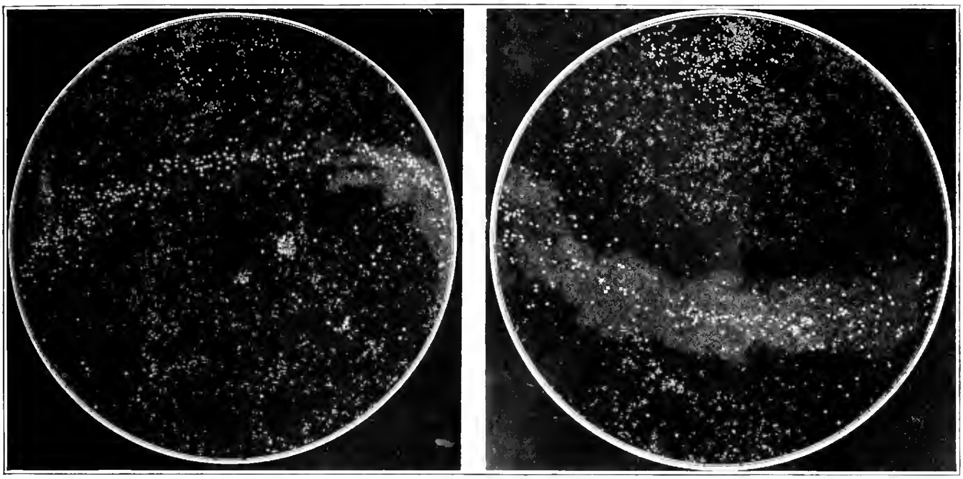


FIG. 4. THE GREAT STAR CLUSTER IN HERCULES. Photographed at the Mount Wilson Solar Observatory.

read that the nebulæ in general abhor the Milky Way. In the northern hemisphere they cluster most densely in the neighborhood of the pole of the galaxy. In the southern hemisphere they show the same tendency, but not so strongly. There are nebulæ in the Milky Way, but



SOUTHERN HEMISPHERE. NORTHERN HEMISPHERE.
FIG. 5. DISTRIBUTION OF NEBULÆ (AND STAR CLUSTERS). According to Proctor. Nebulæ are marked by dots; clusters by crosses.

they are relatively few. Herschel's and Proctor's conclusions related only to the brighter nebulæ, which had been discovered by visual methods.

Before Keeler began to photograph nebulæ with the Crossley reflector, in 1898, some 10,000 of these bodies had been discovered and catalogued. A few plates exposed by Keeler here and there over the northern sky recorded several hundred additional nebulæ. Using his photographs of small areas of the sky as samples, he estimated conservatively that at least 120,000 nebulæ are discoverable with the Crossley reflector. Further observations by Perrine with the same instrument and by Fath with the 60-inch Mount Wilson reflector have shown that the number discoverable with fairly short exposures is considerably greater than 120,000. Fath's plates, uniformly distributed over the northern sky from the North Pole to declination 22°.5 south of the Equator, recorded 864 nebulæ previously unseen. The numbers on the individual plates are set down in the corresponding area. The curve drawn across the chart represents the central line of the Milky Way. The north pole of the galaxy is at N. The distribution of these faint nebulæ is seen to be patchy, but the fact is in evidence that the faint nebulæ, like those bright enough to be discovered by visual methods, abhor the Milky Way.

Keeler's photography of the nebulæ led him to open another chapter in nebular investigation with the startling discovery that "most of the nebulæ have the spiral structure." This applied not only to the faint nebulæ which he discovered, but to the nebulæ already known. Keeler's successors have confirmed this discovery: it is certain that the great majority of the nebulæ have the spiral form. What the relative number of spirals and formless nebulæ may be remains for the future to de-

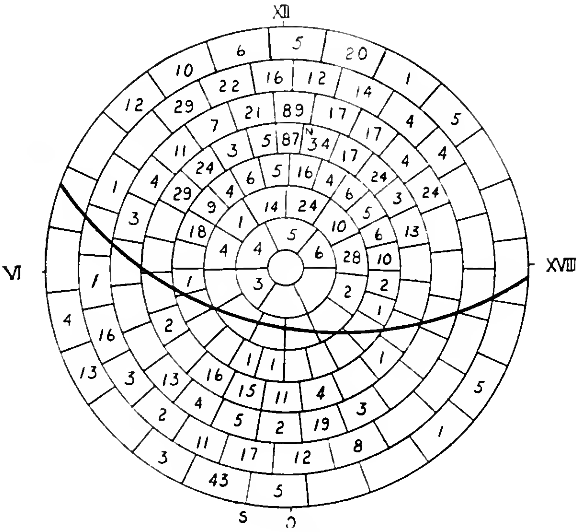


Fig. 6. Distribution of Faint Nebulæ discovered at Mount Wilson.

cide. The spirals vary all the way from the great Andromeda nebula down to those so small that the photographic plate is just able to separate the details of structure; and there is no reason to doubt that more powerful instruments would show still smaller objects to have the spiral structure.

There are irregular nebulæ of all sizes. The brilliant Orion nebula is diminutive in size compared with the faint nebulosity, discovered by William H. Pickering in 1889, which forms the background for almost the whole of the constellation of Orion. The well-known nebulous structure connected with the brighter Pleiades stars is small in comparison with the area covered by a faint exterior nebulosity discovered by Barnard in 1893. There are very great irregular nebulæ such as the Network Nebula in Cygnus and the nebulous background in the Greater Magellanic Cloud. Barnard's wonderful photographs of the Milky Way have recorded many extensive nebulous fields, especially in regions where the background of the galaxy shows relatively few stars (see Fig. 2).

The so-called planetary nebulæ are of special interest, as we shall learn in the sequel. Small in size, all more or less dense, some quite

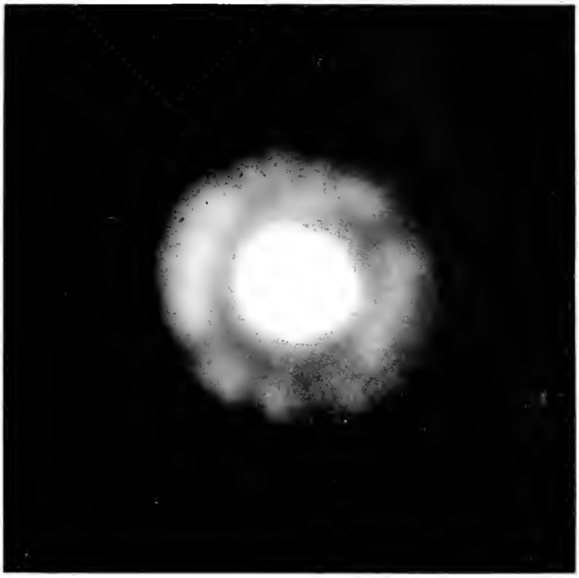


FIG. 7*a*. PLANETARY NEBULA, N. G. C. 2,392. Photographed at the Lick Observatory.

FIG. 7*b*. PLANETARY NEBULA, N. G. C. 40. Photographed at the Lick Observatory.

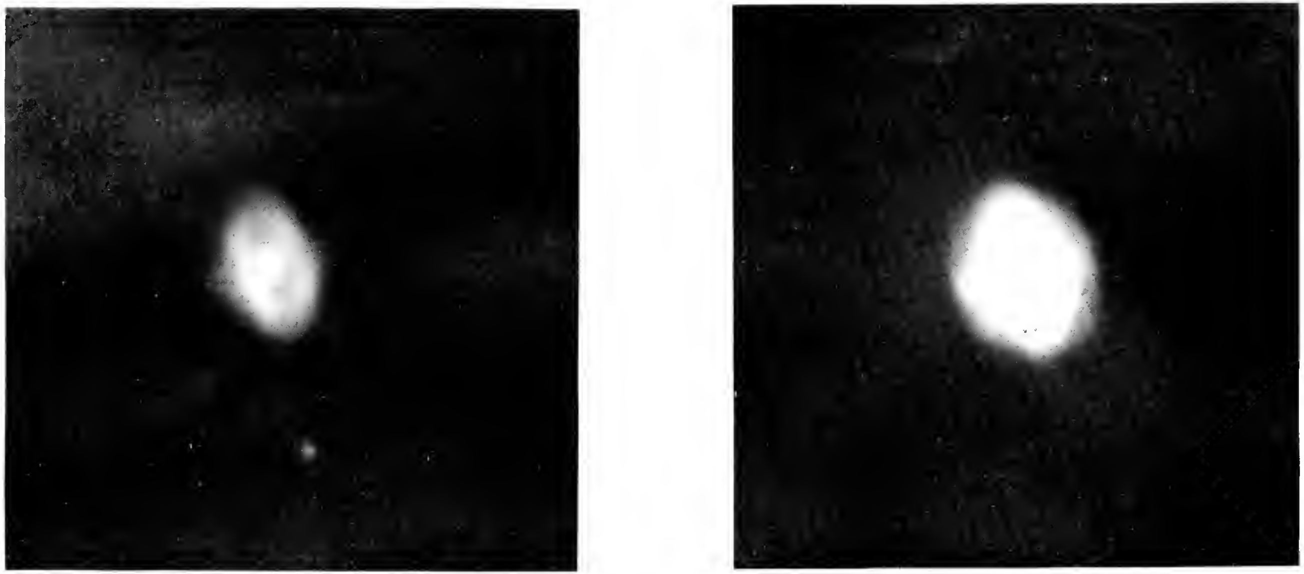


Fig. 7c. Planetary Nebula, N. G. C. 7,009. Photographed at the Lick Observatory. Two exposures, one short and one long.

regular in outline, and a large proportion containing condensed or stellar nuclei near their centers, they were called planetaries by Herschel, because, though faint, they present discs somewhat as the planets do, when viewed under low power.

There are several scores of so-called stellar nebulæ. In moderate-sized telescopes most of them look like ordinary stars. In large telescopes many of them are hazy, but some are as well defined as stars. The spectroscope shows that all are true nebulæ. If they were much closer to us we should doubtless see them as planetary nebulæ.

A few other interesting objects are known as ring nebulæ, the most noted case being the ring nebula in Lyra.

Among the remarkable facts of the stellar universe are these: the large irregular nebulæ, the ring nebulæ, the planetary nebulæ, and the stellar[4] nebulæ, with relatively rare exceptions, are in or very close to the Milky Way: and, on the contrary, the spirals in or near the Milky Way are of negligible number. The first group are without question an integral part of our stellar system. The spirals, seem not to be closely connected with our stellar system, yet their very avoidance of the Milky Way shows that they bear some intimate relationship to it. There is no occasion for surprise that a small group of special objects should be in the Milky Way structure; but that the scores of thousands, and perhaps hundreds of thousands, of spirals, should abhor the Milky Way is a fact which immediately arrests our attention and calls for explanation. Moore has suggested that their absence from the Milky Way may be apparent and not real: that any absorbing or obstructing medium in the Milky Way structure might prevent the light of the spirals from reaching us, especially if the spirals are extremely distant. If the light from very distant nebulæ is absorbed or obstructed, as a function of the angular distance from the galaxy, the nebulæ near the poles of the galaxy, other things being equal, should on the average be intrinsically brighter than the nebulæ in or near the Milky Way. Secondly, if such an effect exists, long-exposure photographs on regions near the galaxy should record nebulæ in numbers more nearly equal to those recorded by short exposures near the poles of the galaxy. An examination of existing Crossley reflector photographs has led to negative results on this question, and we must assume that the spiral nebulæ really avoid the Milky Way.

The question of the distances of the spiral nebulæ has long been held in mind. The evidence, to which we shall refer later, is to the effect that they are very far away, and accordingly that they are of enormously

[4] The terms irregular, ring, planetary and stellar are intended merely to differentiate these objects as to their appearance in the telescope or on the photographic plate. They do not in themselves indicate differences in constitution or physical condition. The ring, planetary and stellar nebulae have a great many characteristics in common.

Fig. 8. The Ring Nebula in Lyra. Photographed at the Lick Observatory.

Fig. 9.—Spiral Nebula in Canum Venaticorum, M. 51. Photographed at the Lick Observatory

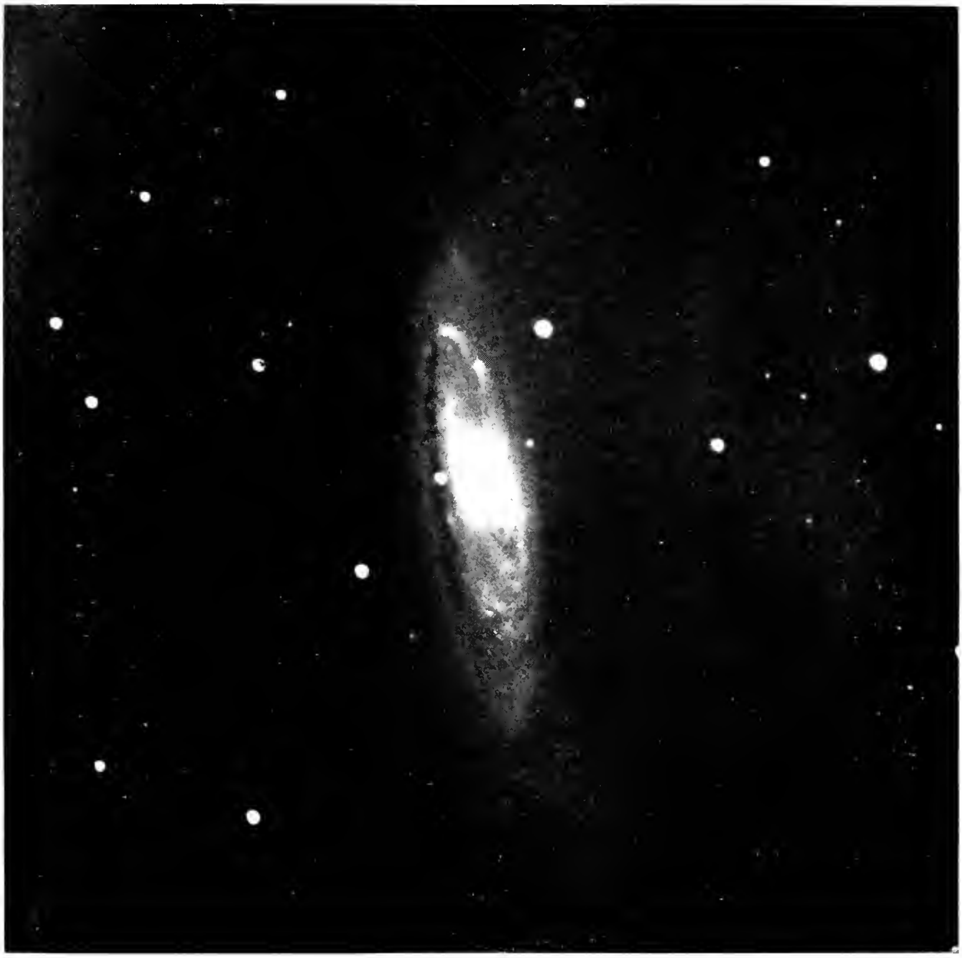


FIG. 10. SPIRAL NEBULA IN LEO, M. 65. Photographed at the Lick Observatory.

great dimensions. This is the particular reason why a few astronomers suggest that the spirals may be distant systems of stars. They say that our own stellar system, if viewed from a great distance, might be seen to have a spiral structure: that it would be fairly circular in general outline if viewed from the poles of the Milky Way, or greatly elongated or spindle-shaped if the observer were in the plane of the Milky Way. We illustrate this point by means of well known spirals viewed broadside, and obliquely, and of the spindle-shaped nebulæ, which we do not doubt are spirals seen edgewise. Easton, the principal modern student of Milky Way structure, has even gone through the laborious task of assigning the stars, as seen from our viewpoint near the supposed center of the stellar system, to their assumed places in a spiral structure. But I need scarcely say that the subject is too vast for solution now, or in the near future. If our stellar system is one of a hundred thousand or more spiral nebulæ, we have at once the problem of determining the place of our stellar system in the larger universe of systems, necessarily beginning with the motion of our system as a whole with reference to the great numbers of surrounding systems.

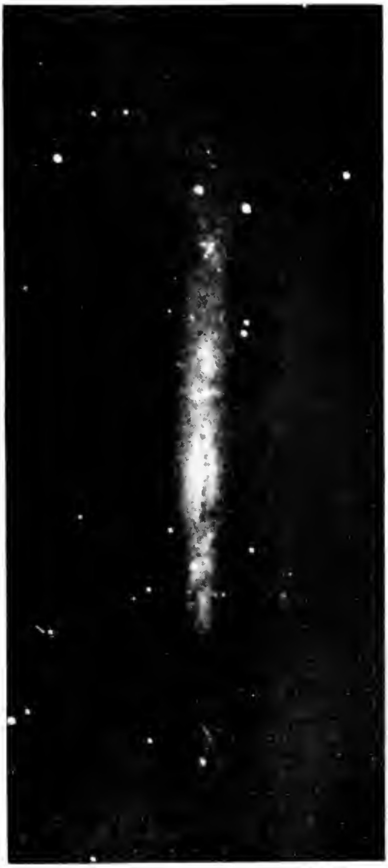


FIG. 11. THE SPIRAL NEBULA H. V. 41, *Canum Venaticorum*, seen edgewise. Photographed at the Lick Observatory.

STAR STREAMS

It was supposed, until ten years ago, that the stars are moving approximately at random, both as to direction and as to speed. In 1904 Kapteyn announced, on the contrary, that the stars have decided preferences for motions toward two opposite points in the sky: one point in the northern edge of Orion, in the Milky Way; and the other point exactly opposite to this. Investigations by many others have in all cases confirmed Kapteyn's discovery. Kapteyn did not mean to say that the individual stars are moving parallel to a straight line joining these two

opposite points, but simply that their components of motion parallel to this line are considerably greater, on the average, than the components in any other direction. We may visualize his ideas in the following manner:

Assume the existence, ages ago, of a great cluster or cloud of stars distributed more or less uniformly through a certain vast volume of space, whose individual motions were at random in both magnitude and direction. Assume the existence of an entirely similar group of stars, occupying another vast volume of space, whose internal motions were also at random. Assume, further, that these two groups of stars were traveling through space in such a way that they more or less completely interpenetrated, with the result that the two groups of stars have now become a single group. There are stars still moving in all directions, with speeds of all dimensions within certain limits, and yet there exists a preference for motion along and parallel to the line which originally joined the centers of the two groups. Assume now that our Sun is carrying the terrestrial observer through the combined group in a direction making a considerable angle with the line of preferential motion: the apparent motions of the individual stars, as observed from the solar system, would then have preferences for two directions very different from the line joining the two original positions of the groups; we should find a great number deviating by small angles from the two preferential directions, a small number deviating to a greater extent, and relatively few whose motions make large angles with the preferential directions; and this is as the apparent motions of the stars have been determined by many observers.

Kapteyn's results depend upon proper motion data; that is, upon their apparent motions on the surface of the sky. Spectroscopic observations of stellar motions of approach and recession confirm that the stars have preferential motions, but to a smaller degree than proper motion data had indicated.

No one doubts that preferential motions exist, but the explanation is another matter. Kapteyn does not insist that our stellar system has actually resulted from the intermingling of two star streams, yet he inclines more and more to this point of view, and the hypothesis does seem to accord better with the observed facts than any other hitherto proposed. A strong objection to it is its apparent improbability. It does not seem reasonable that two great clouds of stars, containing all the stars now in our sidereal universe, should have come together and interpenetrated so completely as to have produced in an age when we happen to be the observers a stellar system apparently spheroidal in form. When I look at the Milky Way, completely encircling the sky, my mind is filled with doubt. And if two great galaxies of stars have traveled far and come together, they will travel further and through each other and we shall have two galaxies again, moving away from each other. It does

not follow that the more distant and fainter stars will show the same preferential motions as the brighter and nearer ones which led Kapteyn to his hypothesis, though it should be said that a fairly extensive study of stars fainter than the Kapteyn stars made by Comstock led to results in good agreement with Kapteyn's. May it not be possible that the preferential motions observed are in some way connected with rotational phenomena within our stellar system, especially as the line of preferential motions lies approximately in the plane of the Milky Way, or are local to what we may call our region of the system, and not be true of the system as a whole?[5]

An alternative hypothesis of prevailing stellar motions, proposed by Schwarzschild, seems to have advantages from the point of view of probability, but it appears not to accord so well with the facts of observation. Schwarzschild suggests that if from a given point we draw vectors whose directions and lengths represent the directions and speeds of existing stellar motions, then the outer extremities of these vectors will define the surface of an ellipsoid (of preferential motions) having three unequal axes.

(*To be continued*)

[5] Turner has proposed the following explanation of the two star streams: The whole mass of the stellar system exerts a gravitational influence on the motion of each star in the system, and the individual stars revolve around the center of mass of the system in their elongated orbits. One star stream comprises all those stars moving away from the center, and the other stream all those stars moving toward the center. We can not doubt that the motions of the individual stars are influenced by the gravitational attractions of the stellar system and of the group of stars nearest to them; but observational data on stellar motions must be vastly more extensive than at present in order to test Turner's hypothesis.

Halm, of the Cape of Good Hope, has given evidence of the existence of a third star stream, much less extensive than Kapteyn's two streams.

ANT-HILL FOSSILS

By Professor RICHARD SWANN LULL

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LAST summer it was the writer's privilege to lead a small expedition from Yale to the fossil fields of the west in search for the relics of bygone creatures to add to the already extensive collections owned by the university. Our purpose was not solely that of collecting, however, but to get data concerning the distribution in time of certain of the ancient faunas, hoping thereby not only to increase the sum of our knowledge, but to date more accurately some of the wealth of forms collected by the pioneer expeditions which, under the leadership of Professor Marsh, penetrated the unknown west in the early seventies.

The work was partly in Nebraska exploring the Tertiary rocks for the remains of warm-blooded mammals—horses, camels, rhinoceroses, elephants, and their kindred—and partly in eastern Wyoming, where one finds sediments of greater age containing the earthly inhabitants of the closing years of the Age of Reptiles. The mammal collecting is an old, old story, but the work in Wyoming had many novel features and forms the theme of this brief essay.

The Mesozoic rocks, those of the Age of Reptiles, are exposed with their contained fossils in many places in this broad earth of ours, but nowhere to a greater advantage than in the west, and this is particularly true of the states of Wyoming, Colorado and Montana. One of the counties of eastern Wyoming, formerly called Converse county, is now divided into two portions, of which the westernmost retains its ancient name, while the eastern part has been called Niobrara after the long Nebraska river whose source lies here. The latter county includes one of the most notable of Mesozoic localities, the beds lying on either side of the confluent Lance and Lightning creeks. The former of these is a tributary of the Cheyenne river, through which its waters flow into the Missouri on their long journey to the Gulf.

The strata here exposed belong to the ultimate phase of the Cretaceous period, marking the very close of the Reptilian age and possibly its passage into the Age of Mammals. They cover an area of more than sixty square miles, and, because of their geographical locality, have received the name of Lance formation, though they have been called variously Converse County beds and Ceratops beds, the latter name having reference to the most characteristic fossils, the horned dinosaurs or Ceratopsia, whose huge three-horned skulls are the most remarkable

features of the formation. Our camp lay near the only available water-hole, in an otherwise dry canyon, tributary to Buck creek, which forms the eastern boundary of the area. From Buck creek the land rises gradually to the summit of the divide, whence it falls away to the level of Lance creek on the west. On the eastern slope the strata, which dip toward the west at an angle of about ten degrees, form a succession of outcrops one above the other as one ascends the hill, so that they may be read in orderly sequence beginning with the oldest in the point of time. Beyond the divide the dip of the strata and the slope of the ground coincide so that the revealing outcrops are absent. To the east of Buck creek, on the other hand, on either side of the little canyon wherein our

FIG. 1. LOOKING DOWN SPRING CREEK CANYON TOWARD THE CERATOPS BEDS. In the foreground and middle distance the strata are of marine origin—Pierre and Fox Hills formation—the fresh-water Lance sediments lying beyond.

camp was pitched, the rocks, while still late Cretaceous, are older than the Lance formation and of marine origin, for in them the shells of ancient sea-creatures are abundant.

Geologists tell us that during Cretaceous time the continent of North America was covered in part by an inland sea having its outlet to the north into the Arctic Ocean and on the south into what is now the Gulf of Mexico. Along the western shores of this Cretaceous sea were long stretches of low-lying lands gradually rising toward the west to the region of the Rocky Mountains, then in their nascent state. The shore lands, which rarely extended much above the level of the sea, were

subject to occasional inundation when the advancing waters covered what had been land, while their retreat laid bare wide areas which had been submarine. The evidence of this was before our eyes, for as we went westward down the canyons, the sea shells would betray the marine origin of the strata, then as we climbed the slope beyond Buck creek we could see the older sea-borne sediments pass beneath the newer

Fig. 2. Lignite Beds in the Lance, indicating the abundance of vegetation.

Lance formation and become replaced by shales and sandstones of fresh-water origin. Occasionally one came across beds of lignite or woody coal which pointed to an abundance of vegetation, either forest or swamp lands wherein plants must have grown luxuriantly.

Out of this classic locality have come the remains of a host of creatures, the inhabitants of the shores of the old Cretaceous sea, many of which are now preserved in the Peabody Museum at Yale, the spoil of former expeditions. These are mostly dinosaurs, land-living reptiles

which flourished throughout the Mesozoic, but which are here represented in the climax of their evolutionary career. Some were huge-headed forms, armed on the snout and above the eyes with horns like those of cattle and with a wide bony crest which protected the neck. These were quadrupeds of rhinocerine proportions, but of much greater size. Others were bipeds with a long tail which served to balance the body when running on land and was a very efficient propelling organ when stress of circumstance made it necessary to take to the waters for retreat. This second group was armor- and weapon-less, with a curious duck-like expansion of jaws, toothless in front but with a wonderful battery of more than two thousand teeth in the rear of the mouth. Occasional mummied carcases have been found which betray the defenseless condition of the scaly skin. Both of these groups were plant feeders, but a third sort, again erect on the hind limbs, bore teeth and claws which can only mean a rapacious flesh-feeder, doubtless the arch-enemy of the other two. These carnivores were represented by small, agile forms, and by others which were truly gigantic.

The dinosaur remains are pretty widely spread over the present area, the horned skulls generally occurring in hard concretionary masses of sandstone, many of which were collected and shipped to New

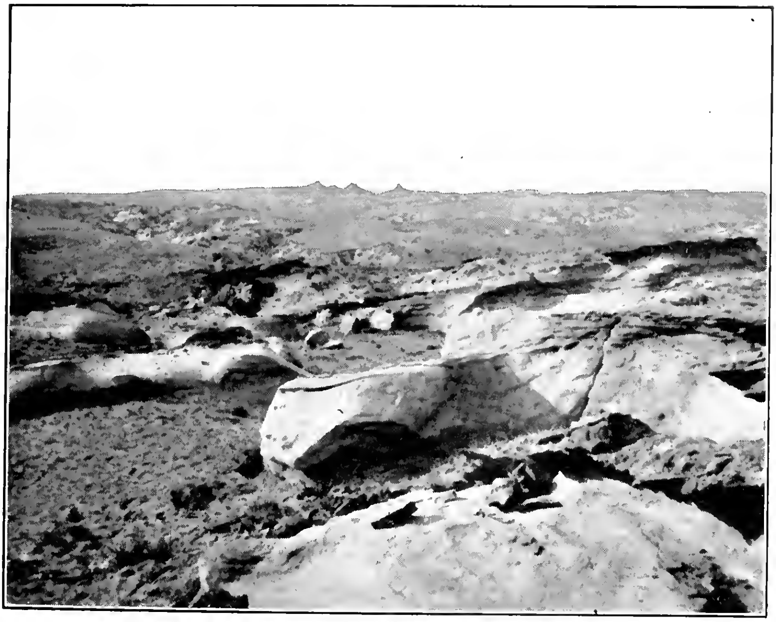

FIG. 3. MASSIVE SANDSTONE WITHIN WHICH THE DINOSAURS ARE ENTOMBED.

Haven and later to the National Museum in Washington, where the contained fossils were freed from the investing rock. Most of the

dinosaur material from this region was collected by John B. Hatcher, a graduate of Yale, and so thoroughly was his work done that very little sign of them now remains. What we of the present expedition especially desired, however, was not to find more dinosaurs, but to hunt for the remains of the tiny mammals, the forebears of the warm-blooded, furry quadrupeds of to-day, which carried on a precarious existence in the midst of such stalking terrors as the giant reptiles.

These mammal remains are known from but few Mesozoic localities and are valued proportionately. By some lucky chance it was discovered that, although they might be found imbedded in the sediments, the most productive places, curiously enough, were the ant-hills. These are numerous and large though in no way differing from those I have found in New England except in the contained fossils. The ants are a lusty breed, valiantly uniformed in brown and black, and with very effective stings, as we have good reason to know. In building their formicaries they not only collect material from the surrounding surface, but in excavating their subterranean galleries the sand and other

FIG. 4. A FOSSIL-BEARING ANT-HILL IN WHICH THE BONES AND TEETH OF THE TINY WARM-BLOODED MAMMALS ARE FOUND.

particles are deposited on top of the growing pile. This was generally a very symmetrical cone with the entrance almost invariably on the eastern side, part way up the slope, while on the western and northwestern aspects the grains of sand were somewhat coarser. We found, however, on breaking into the nest, that the immediate surface was somewhat hardened so as to be distinctly crust-like, while within, until one came to the well-built tunnels, coarse and fine sands were inter-

mingled. It seemed as though the outer crust and the coarse character of the sand on the exposed surface were merely the result of wind and rain which eroded away the finer particles and compacted the surface, and the evidence of the coarser grains on the westward side simply pointed to the removal of somewhat heavier material here than elsewhere by the prevailing westerly winds. I imagine that these winds were also the determining factor in the placing of the entrance, although the idea that the warmth-loving insects might thus have welcomed the rays of the rising sun did occur to me.

It has been found that in addition to ordinary sand-grains certain of the ant-hills also contain fossils, tiny teeth, bone fragments, and in rare instances perfect bones which the ants had unconsciously collected and which have been the source of much of our knowledge of the smaller forms which were contemporaneous with the giant reptiles. It was toward these ant-hills, therefore, that our attention was turned, indeed, they were the object of our journey. I had a rather imperfect map of the region which was supposed to show the place where each important dinosaur specimen had been found and to indicate in a general way the mammal-producing areas. With its aid a very thorough exploration was made, the great majority of the localities which were marked being searched for ant-hills, and these in turn for fossils.

The older method was to shovel the contents of the formicaries into sacs and leave them until the following day, when the ants would have left the material, and then to sift it very carefully, searching for the minute remains of organic life. Much of the "pay dirt" was shipped directly to New Haven, where it could be investigated more thoroughly than was possible in the field. Our time, however, was very limited, so that such refinement of method was impracticable. Then, too, we were not so intent upon adding to the already great collection at Yale as upon determining the exact stratigraphic sequence of the mammal-bearing beds with reference to the geologic column. We therefore attacked the ants' stronghold at once, going over the surface material very carefully, taking the precaution, however, to put a little earth into the entrance and pat it down, thus reducing to a minimum the number of available defenders. The sand was then passed through a common flour sifter and the residue carefully examined, the tiny teeth and bones being removed with a pair of forceps. We did not come away unscathed, for though we brushed aside all the ants we saw, the task would become so absorbing that before one knew it an ant would fix her jaws into the skin and, turning the abdomen under, insert the short but thoroughly efficient sting. After sifting the material we generally replaced it about as it had been found and, as the ants were uninjured, their fabric was probably soon restored to its former symmetry by the tireless little workers, for whom we had a very respectful sympathy in spite of our wounds.

Near Buck creek itself the ant-hills contained only small sharks' teeth, showing that they were still built over marine beds. Then as one mounted the divide and with it crossed higher and higher strata there was a long interval of totally unproductive formicaries, until the principal bed of lignite was reached, and above this, at a vertical distance of ten to fifteen feet, the best of the ant-hills were found, which contained among other remains the bones, scales and teeth of fresh-water fishes allied to the gar-pikes living to-day in southern rivers. These were carefully preserved for comparison with the mammal-bearing sands at Yale collected by the older expeditions, and which were found later to include, in addition to the mammals, fossils exactly similar to those which we secured at this time. That we had found an old locality was further proved by indications of a former camp, fire wood, rusted tin cans, and in an adjacent ant-hill tiny, worn fragments of an unfortunate investigator's spectacles!

The mammalian relics which were thus found were of very small size, consisting of individual teeth or a fragment of a jaw with one or more teeth still in position, or other portions of the bones. Mammal teeth are fortunately highly indicative of habit and relationships; but on the other hand, in collections of this sort, not one bone can be associated with another. Thus, while some idea of the general size and method of feeding may be obtained, no attempt to restore the skeleton or even the entire skull is possible. In size none of the ant-hill mammals was larger than a rat, and many were much smaller. Those whose teeth bore few sharp-pointed cusps were carnivorous, feeding on such feeble folk—insects, worms, and possibly other mammals—as they could overcome. Others with chisel-shaped incisors and many-cusped grinding teeth were plant-feeders, probably living not only on tender leaves, but on berries and the seeds of berries and other fruits.

The little glimpse of a former geologic age which this trip gave us was full of suggestive detail. I have already described the scene as the scientific imagination conjures it up, the broad, savanna-like, low-lying lands over which wandered the huge reptiles then at the very culmination of their evolution. But what of the mammals? Where were they and how did they survive the competition with the dinosaurs? Possibly their very insignificance was their chief safeguard, just as countless small rodents and insect-eating creatures live to-day in the lion- and buffalo-haunted African jungles. Possibly they were tree-inhabitants, and the location of the mammal-bearing ant-hills near the lignite certainly suggests an abundance of near-by vegetation. However we may interpret it, the evidence is clear that these mammals and the dinosaurs were contemporaries in the same general locality though the exact environmental conditions under which they lived may have differed.

Passing back in time some millions of years further, one finds in

rocks which mark the beginning of Cretaceous time as they are exposed in another Wyoming region one hundred miles or so to the southwest, this same association of mammals and dinosaurs, but many of the latter are very unlike their successors and include mighty forms which soon became entirely extinct. But the mammals are practically the same, with little evidence of change, while the reptiles are undergoing their most remarkable evolution.

Again we find the mammals at the close of the preceding Triassic period, this time far to the eastward in South Carolina and then in Germany and South Africa, not in direct association with dinosaurs, but nevertheless in contemporary strata with some of the most primitive of the race. Thus these forebears of modern beasts and men live long ages without measurable progress, while reptilian dynasties wax and wane. But the mammals, with the tenacity of their race, are merely awaiting their opportunity, although so effective is the check laid upon them by their cold-blooded contemporaries that for them evolution practically ceases while the march of time goes on. At last comes the day of reckoning when, due to some cause or causes of which we have not yet learned the nature, although they were doubtless conditioned upon the mountain-making revolution which closed the Age of Reptiles, the dinosaurs, after their multi-millennial career, are blotted out and the Age of Mammals is begun. Now from their fastnesses stream the furry hosts, impelled by age-long earth hunger, to fill every station in the economy of nature which the reptiles had possessed, and now the evolutionary mill, turning faster and faster, grinds out the beasts both small and great which become in their turn the rulers of the earth until their place is usurped by humanity.

FOUR POINTS IN THE INDICTMENT OF THE SMOKE NUISANCE

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IN all papers and talks concerning the smoke nuisance, it has become customary to refer to the economic cost of the nuisance both to the public and to the smoke makers. This is the indictment which is supposed to strike home. When a speaker on this subject says

> The abolition of the smoke nuisance, unlike many other social nuisances against which outcry has been, would result in direct and immediate gain both to the public at large and to those who are chiefly responsible for the nuisance itself,

he feels that he has said the last word.

There are other points in the indictment of the smoke nuisance to which attention may more properly be directed. It is the purpose of this paper to tell of the present knowledge on four of these points, namely:

1. The effect on building materials.
2. The effect on meteorological conditions.
3. The effect on vegetation.
4. The effect on health.

There has been much talk within the last few years concerning city planning. The principal idea that city planning seems to convey to most people is a beautiful and costly square, set in the center of an ugly city. All real city planning should have as one of its main objects the purification of the atmosphere. Some forty years ago, John Ruskin, speaking to the Society of British Architects, said:

> All lovely architecture was designed for cities in cloudless air. . . . But our cities, built in black air, which, by its accumulated foulness, first renders all the ornament invisible in distance, and then chokes its interstices with soot; . . . for cities such as these, no architecture is possible.

An architect in a smoky city is forced to take atmospheric conditions into account. Drain pipes must be arranged with great care—that there may result no splashing of the soot-carrying water to discolor the sides of the building. Mouldings must be so designed that the rain will not wash over the face that soot which collects on top of the mouldings. Drips must be provided on all projections. Under-cutting, delicacy of incised line and sharpness of angular forms must be foregone, for the soot deposited will, in time, fill up the crevices and mar the

beauty of the outline, causing considerable alteration of the original forms and making the building degenerate into a mere mass of dirty, shabby masonry.

It is rather interesting to note the vogue of such materials in buildings as glazed brick and terra cotta, in smoky cities. Stone, for which they are substitutes in many cases, is injured by smoke and the associated products of combustion in two ways:

1. The soiling of the surface, so that in the course of a few months all stone takes on the same gray, grimy color. This means either the loss of all artistic effect that may have been obtained by color contrast, etc., or the frequent cleaning of the building, which is an additional expense and at the same time aids in the destruction of the stone.

2. The actual destructive action on all stones by the acid products of the combustion of the coal. This is especially marked on any stone containing calcium or magnesium carbonates in larger or smaller quantities. Although there is some action on other constituents of the building stones, it is so slow in most cases as to be hardly noticeable.

A study was made in connection with the smoke investigation of the Mellon Institute as to the effect of smoke on outside painting.[1] Both the effect on paint as a protective coating and as a decorative covering was considered. It was found that some paints last comparatively longer in Pittsburgh than in many other cities. This is in part due to the protective action of the soot in preventing the destructive action of the active rays of the sun. This would also indicate that such paints might afford a lodging place for fungi, which grow in the absence of direct sunlight.

It was found that smoke darkens paint coatings very rapidly and renders the use of light colors unsatisfactory on account of the short time they retain their true color. Analyses of the surface of the paints showed that the darkening was due to sulphur dioxide gas and to the accumulation of soot, carbon and similar organic matter contained in smoke.

The effect of smoke on metals must be taken into consideration in connection with the other building materials. When soot containing tar comes in contact with a metallic surface, it is made to adhere more or less firmly by means of its tar content. The occluded acids, principally sulphuric and sulphurous, are thus brought in intimate contact with the metal, giving a much better chance for corrosive action to take place and for it to become complete quicker than if the same amount of acid dissolved in rain water came in contact with the metal. The acid in the rain water drains off readily, while the soot protects the occluded acid to a great extent, so that it remains in contact with the metal until it has all been used up.

[1] Benner, Raymond C., Bulletin No. 6, "Papers on the Effect of Smoke on Building Materials," 1913. (Published by Mellon Institute.)

Inquiry in Pittsburgh among metal workers developed the fact that metal work in a smoky city lasts only half as long as in one free from smoke.

It is hardly necessary to point out that smoke damages the interior decorations of a building or home, limits interior decorators in the use of colors and materials and in every way tends to render artistic effects gloomy and depressing.

Cities very properly hold favorable climatic conditions as a very desirable asset, as is evidenced by the records of rainfall, temperature, fog and hours of sunshine which appear in the year books of the chambers of commerce and boards of trade of the different cities. Cities which have smoky atmospheres are under a severe handicap in this regard.

In the first place, while smoke is not a cause of fog, it intensifies a fog when it is once formed and accordingly causes it to persist longer.[2] In consequence of this there are fewer hours of sunshine in smoky cities than in cities which are practically free from smoke. Again, the sunshine is less intense in smoky cities, the light of short wave lengths, or the blue light, suffering the greater depletion. Not only is this true, but daylight, which depends entirely upon diffused light from the sky, is depleted by the smoke in greater proportion than the direct sunlight.

Experiments carried on by the Smoke Investigation of the Mellon Institute in Pittsburgh and Sewickley, a small residential town on the Ohio River, about twelve miles northwest of Pittsburgh, during 1913, revealed that Pittsburgh had 25 per cent. less sunlight and 40 per cent. less daylight than Sewickley. It was also found that the limit of visibility in the business section of Pittsburgh was about one tenth the limit in the open country. It is well known that the frequency of intense fogs in London has decreased and the hours of sunshine increased since 1890, due to a mitigation of the smoke nuisance. The same was true of Pittsburgh between 1885 and 1895, when the use of natural gas for manufacturing and domestic purposes was quite general.

A number of studies have been made of the effect of soot on vegetation. Cohen and Ruston, as a result of their researches in Leeds, England, declared that soot may exert a detrimental effect on the growth of plants in three ways, namely, by blocking up the stomata and thus impeding the process of transpiration; by coating the leaf and so reducing the intensity of sunlight, and at the same time affecting the assimilation of carbon dioxide; and lastly, by the corrosive effect of the acid it contains.[3] Experiments they carried on went to show that the power of assimilation of laurel leaves had a definite relation to atmospheric

[2] Kimball, Herbert H., Bulletin No. 5, "The Meteorological Aspects of the Smoke Problem," 1913. (Published by Mellon Institute.)

[3] Cohen, Julius Berend, and Ruston, Arthur G., "Smoke: a Study of Town Air," 1912.

impurities, that crops of radishes and lettuce grown in different sections of Leeds show the possibility of correlating the known atmospheric impurities with the yield of the crop. They also found that as trees automatically keep a record of yearly growth, the presence of any inhibiting factor will make itself known by the narrowing of the annual rings.

In 1913, a study of the effct of city smoke on vegetation was made in Des Moines by A. L. Bakke, of the Iowa State College.[4] Mr. Bakke reached the following conclusions:

1. That gases and smokes have a deleterious action upon vegetation.

2. That the vegetation about a manufacturing concern may be mapped off, in the form of concentric belt demarcation, each belt being represented by a certain form or forms of plant life, since certain plants are more susceptible to smoke injury than others.

3. That an industrial city like Des Moines, in its plant elimination process, is governed by the same set of conditions as are in operation for a single manufacturing plant.

Mr. J. F. Clevenger, as a result of his studies in connection with the Smoke Investigation of the Mellon Institute, declared that the fact that smoke injures vegetation is evidenced not only by the general external appearance of many of the constituent plants, but also by their internal appearance, as shown by the size of annual rings and by lesions in the leaves.[5] Mr. Clevenger's studies were confirmed by controlled field experiments which he made. In these experiments growing plants enclosed in cases were subjected to small quantities of soot distributed uniformly over them. The leaves of the plants so treated displayed a tendency to drooping and many of the leaves began to die at the tips; a checking of growth of the plants was also apparent.

The effect of smoke on health has been a much-mooted question. For a long time it was held, and still is by some, that a smoky atmosphere is not injurious and at times even beneficial to public health. This supposition gained favor from an observation, largely erroneous, that coal miners are not prone to contract tuberculosis.

One of the most comprehensive studies of the direct effect of smoke upon the respiratory organs was made by Dr. Louis Ascher, of Königsberg. Dr. Ascher's statistical and experimental studies led him to the conclusion that the mortality of acute lung diseases is certainly increasing, especially among children and old people. The cause of this increase, he declared, is the impurification of the air by smoke, as the increase is greatest in industrial centers and not in agricultural districts. He further pointed out that within industrial districts a difference in

[4] Bakke, A. L., "The Effect of City Smoke on Vegetation," Bulletin 145, Iowa State College of Agriculture.

[5] Clevenger, J. F., Bulletin No. 7, "The Effect of the Soot in Smoke on Vegetation," 1913. (Published by Mellon Institute.)

mortality can also be noted, the death rate from acute lung diseases, in districts with much smoke, being higher than in other industrial centers with little smoke as textile districts.

The physicians who worked in cooperation with the Smoke Investigation of the Mellon Institute made valuable contributions to the question of the relation of smoke to health.[6]

Dr. W. L. Holman, investigating the bacteriology of soot, arrived at the following conclusions:

1. Soot has a definite bactericidal action on bacteria, due either to the absorption of moisture from the organisms or more probably to the action of its contained germicidal acids and phenols.

2. Soot, as it occurs in smoke, clouds, fogs and as a non-transparent covering for our streets and houses, protects microorganisms from the destructive action of sunlight.

Dr. Oskar Klotz, attacking the subject from the viewpoint of a pathologist, asserts that pulmonary anthracosis—a term applied to a condition in which carbon particles of extraneous origin are deposited in the lungs—is an urban disease and is proportionate to the smoke content of the air. His examination of the lungs of adult individuals resident in Pittsburgh shows that they have materially more carbon deposit than the lungs of individuals resident in a lesser manufacturing community.

Dr. Samuel R. Haythorn, attempting to determine whether or not excessive deposits of dust and coal pigment within the body tissues have or have not any "real disease" significance, arrived at the conclusions:

1. Moderate anthracosis in an otherwise normal lung is not in itself detrimental to health.

2. In tuberculosis, the anthracotic condition is either entirely passive or is active in assisting healing, in that it aids in the localization of the process through the obliteration of the lymph spaces.

3. In the case of pneumonia, the effect of carbon deposits in the lungs is quite different. The carbon blocks up the lymphatic spaces and causes obliteration of the lymph channels. This results in serious intereference with the drainage system of the lungs and thus delays, if it does not make impossible, the resolution of the pneumonic process. An anthracotic lung has, therefore, less chance of recovery from pneumonia than a lung which has not undergone changes from the deposit of carbon.

Dr. William Charles White, from a study of the relation of the mortality from tuberculosis and pneumonia to the smoke content of the air, shows that, in Pittsburgh, pneumonia increases with the density of smoke irrespective of the density of the population or of poverty. Tu-

[6] Klotz, Oskar, and White, Wm. Chas., Bulletin No. 9, "Papers on the Influence of Smoke on Health," 1914. (Published by Mellon Institute.)

berculosis, on the other hand, he shows to be independent of the smoke density, following, as it does everywhere, the line of overcrowding and poverty.

In summarizing the results of all medical investigators whose opinions are based on other groups than theory, it can be asserted that smoke has a tremendous influence in increasing the incident severity and mortality of acute disease of the air passages. It would appear that this increased susceptability is, in part, the result of the lowering of our natural body resistance. In simple terms, the smokier the atmosphere, the more the colds and bronchitis, and the more money paid to doctors.

It would seem from a consideration of the four points that have been discussed that it is high time for the people to arouse themselves from the apathy that they have shown toward the smoke nuisance. The purification of the atmosphere should receive the same attention as pure food and pure water are receiving, for it is just as important. People should be educated as to the evils of the nuisance so that an active and intelligent public opinion could be brought to bear on those who are responsible for it. The demand should go out that the nuisance be abated as a menace to health, property and the things which make for civic betterment.

A CIVIC INVESTMENT

By President P. R. KOLBE
MUNICIPAL UNIVERSITY OF AKRON

IN these modern days of municipal extravagance, of crowded city budgets, and of frantic legislative attempts to control undue rates of taxation in our centers of population, any new source of expenditure is almost pre-fated to encounter the shrug of suspicion—the stony stare of hostility. Even the propagandists of municipal ownership demand their pound of flesh—the new venture must pay for itself in hard cash.

What claim then has higher education upon the purse strings of the city taxpayer? "Support a college with city money?" grunts the rich manufacturer, "Not by a long shot; what this town needs is more paved streets, not Greek and Latin students." Did it ever occur to you that to the average business man all college graduates are "Greek and Latin students"? Many expressions have become so formalized that they are inevitable—they slip from the lips as naturally as "the sunny south" or "the great metropolis" or any other of the thousand and one substitutes which our jaded minds employ in the place of real ideas. So it is with education. All students learn "Greek and Latin," all education is "impractical." Ten to one the man who uses these terms has not been inside an institution of higher learning for years—probably never. If salvation itself were at stake he could not name half a dozen subjects taught in the modern college—"Latin and Greek" he would tell you "Ah, er—yes, Latin and Greek and—well—I really can't say, but anyhow it's all quite impractical!" He doubtless has inherited this idea as he did his politics and religion, but in both of the latter, he has kept more or less abreast of the times. In the case of higher education, though, he has never given the matter sufficient independent thought nor investigation to modify his grandfather's viewpoint, and even the most partisan supporters of education must confess that that old gentleman would perhaps have been right, had he called the education of his day "impractical." In the course of the next few years, I believe, the leaven of the "new education," the actual preparation for life, will have worked itself in to the very center of the lump—will have educated not only its students directly, but working through them, will have inspired a wholesome respect in all the people for the practical efficiency which many of our best colleges are imparting to their charges—all of which brings me back to my real subject, the municipal university.

The municipal university represents one of the newest, the most

modern types of education for the purpose of practical efficiency. With the examples of the great state universities ever in mind, it has realized that the highest mission in its field lies in service to its community. Since the services which education may render to a city are somewhat different from those which it may render to a state, the municipal university has had a new problem to solve or rather should I say—*has* a new problem to solve, since both the conception of the problem and the attempts at its solution are still in their infancy.

Our country to-day possesses only half a dozen municipally supported institutions of higher education. As a matter of fact, in the old sense of the word, we have only one municipal *university*—the University of Cincinnati. Other municipal institutions of collegiate rank (my own among them) have assumed the title "municipal university," in the face of educational disapproval of the term, largely for the reason that our language offers no name to characterize a school which has outgrown the limits of the old fashioned college, which has actually established other schools than that of liberal arts, but which does not possess all the professional faculties. For such institutions, in view of their close cooperation with various city departments and in further view of the fact that a development along practical and technical lines has multiplied the number of their schools to a greater or less extent, the name "municipal university" seems not ill chosen.

The keynote of a municipal university must ever be public service—not that somewhat indefinite public service which gives young people a "broad, general education" (too often a euphemism for a mere smattering of many subjects)—but rather that public service which will awaken in our young people a consciousness of their relation and responsibility to the community and which will actually train them for life and for civic duties.

The recent meeting held in New York at the call of Mayor Mitchel under the auspices of the American Political Science Association's Committee on Practical Training for Public Service discussed as its main topic the service of the university to the community. The same topic engaged the attention of the Urban University Association at Washington last November. This meeting marked an epoch. For years it has been growing more and more apparent that every collegiate institution which exists tax free in the midst of a large community does owe an actual debt to its city. This feeling has doubtless been strengthened by the attitude of a few municipal universities, notably Cincinnati, who have been trying to make some practical return for the money which taxpayers have given them. Just how this can be done is one of our most important modern problems. With the feeling that New York offers an unparalleled field for such activities the New York conference adopted a resolution calling upon the College of the City of New York to institute

a series of experiments along this line, whose results should serve to guide other institutions toward the same goal of public service.

Meanwhile, the middle west has been working out its own salvation as regards the public duties of city bred educational institutions. Ohio with its three municipal universities at Cincinnati, Toledo and Akron, leads its neighboring states in this respect.

When Akron, a city of 100,000 inhabitants, established such an institution upon the foundation of the old Buchtel College, many, good citizens shook their heads in doubt as to whether a city of this size could afford the "luxury" of higher education. Fortunately, however, the young people of the city saw in this opportunity not a luxury but a chance for practical preparation for life. In the two short years of its existence, the university is already beginning to be one of the strongest factors in the community for civic betterment.

Why can a municipal university offer more practical education than other colleges or universities? As a matter of fact, any private institution *can* do as much. The municipal institution has simply by force of its position, heard the call more clearly and for this reason leads the way. Its activities are divided into two general lines:

1. The training of students.
2. Cooperation with city departments and activities.

Either one of these two is impossible without the other. Students can not be trained for practical life without contact with actual conditions. Such contact can only be secured when every department of the university is in close cooperation and contact with that part of civic life to which it is most closely related. On the other hand, such contact can only be secured by putting students directly into the activities mentioned and thus forming the connecting link between city and university.

The beginning of this contact was made at Cincinnati about eight years ago, when Dean Schneider established his courses in engineering on the cooperative plan. It is scarcely necessary here to mention the merits of this much discussed system. In brief, it means that engineering students work for alternate two-week periods in class room and in factories, under actual shop conditions. Thus a graduate from this course is not a mere theorist, but knows manufacturing and engineering from the standpoint of personal experience.

To students of economics and sociology an especially broad field is open for experience with the conditions of actual life. In my own city, a thorough housing survey has been carried on by university students under the joint direction of the department of sociology, the charity organization and the board of health. Nor has this work been mere play with no practical use. As a result of reports brought in by student inspectors, the sanitation of houses and even of whole districts has been improved through vigorous action of the building inspector. The city has been benefitted by enlisting in its service a body of capable in-

spectors at no cost, while the students have received credit at the university for "laboratory" work.

When the city of Akron established its municipal university, it was found that the university laboratory offered better facilities than that of the city chemist. In order to avoid expensive duplication, the university thereupon undertook to carry on in its laboratories the entire testing work of the city and established as one of its departments a bureau of city tests. Again the practical value of cooperation became apparent. Advanced university students in chemistry, instead of working at mere theoretical problems, were given actual city chemical testing work. The difference became at once apparent. A student who plodded through a "book problem" as drudgery, became an active, interested worker in the solution of a real food problem affecting the health of his community. The value of chemistry as an actual factor in life became apparent. At the same time, certain students were receiving experience which would later enable them to enter, well equipped, into a life calling.

When the city council, feeling the need for information, asked the engineering department of the university to undertake a survey of paving conditions in the city, cooperative students were called in to help in the work of inspection. When the need arose for a supervisor of city playgrounds, the physical director at the university was called upon to assume the position. Several of his sub-directors are city university students. Thus the city is beginning to regard the university as a laboratory to which it may, at any time, turn for technical advice and help. Through experience with problems thus offered, students are given the opportunity for training in the service of their community. They are taught to study and know city activities and interests—they become better citizens.

The state university offers free tuition to all who can take advantage of the opportunity. The city university also offers free tuition to its community, a practical training for life, and the advantage of a higher education *at home*. This latter fact opens up possibilities to hundreds of students who could never attend even a state university. A cooperative engineering student, who earns apprentice wages during his alternate two week shop periods and who has the privilege of living at home can secure an education and support himself at the same time.

From all parts of the country come inquiries from cities regarding the operation of a tax supported municipal university. Cleveland has considered a plan by which her students may receive free higher education at a municipal university formed by a coalition of her great privately endowed colleges. The day of the municipal university will come as inevitably as has that of the state university. Municipalities are already beginning to realize the possibilities of *practical* higher education as a civic investment.

SCIENCE AND DEMOCRACY[1]

By M. E. HAGGERTY
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REVOLUTIONS are a part of our modern world. Men have come to look upon them as natural moments in national life. So much experience have the western nations had with social upheavals and the reversal of political practises that they have learned how to revolute without war or violence.

To many thoughtful men, we are now in the midst of such a peaceful revolution. In America, England, Germany, old ideals are being forsaken and settled institutions are submitted to a criticism that unsettles their foundations. Everywhere, in religion, politics, industry, education, there is the antithesis between conservative and radical, the latter bringing about the ears of the former a perfect storm of clamor and bewilderment. In America we incline to view the current tumult as the fallow ground out of which is to spring a new and better form of social organization. The evident unrest is but the symptom of fundamental changes going on. It indicates the recasting of our ideals into a new and larger program of democracy.

Clearly to apprehend the portent of our current confusion, one needs to look below the symptoms for the cause. The fires of significant revolution are never kindled on the surface. They smolder in secret places and in obscurity gather the strength which overturns existing institutions. The overt crisis comes finally as the breaking forth of a long suppressed flame. So was it in France in 1789; so was it in America in 1860; so was it in China in 1912. So is it in all our western world in this year of grace. Causally contributing to our present ferment there

[1] This paper was read to the Indiana University Chapter of Sigma XI, December 11, 1913, and subsequently to the Liberal Lecture League at Indianapolis. On superficial reading it may seem that some of its claims have been refuted by the present European war. To the writer it seems that the development of mankind is a deep movement in which the present war, terrible and reactionary as it is, is an episode. Its most harmful effect upon the march of civic emancipation will be the economic one, the destruction of the means of life. When the "glorious victory" shall have been won there will be less to eat than before. The "strong man" will get his disproportionate share, and the common men who are left in Europe will be hungry. They will be less aggressive than before, and the tide of economic liberation which was steadily rising in 1913 will be stayed. But a new generation will be born to try again the fight for freedom. Some day that fight will be really won and Europe will forget William III. and Nicholas II. as France has forgotten Napoleon and as we have forgotten George III. To the achievement of such oblivion science lends its indirect but powerful aid.

are doubtless numerous causes, but there is probably none more potent than the phenomenal growth of science in the past hundred years. If we are about to have a new democracy it is because science with a thousand charges has shattered old ideas and institutions into fragments and given in their stead the materials for new constructions.

Primary in this relation of science to democracy is the change which has been wrought in the economic status of the men who work with their hands. As not before in the history of mankind, laborers may have food, they may have schools, they may travel and wear good clothes; they may have household conveniences, baths and lighted rooms, unknown to kings and nobles of a century ago. In fifty years our civilization has changed from one of deficit to one of surplus and the specter of a near world famine has disappeared.

For a hundred years following 1798, men were taught that their welfare depended upon the limitation of the population. Malthus had pointed out that the produce of the world could be made to increase in but an arithmetical ratio, while the unrestrained human race was enlarging in a geometrical ratio. The economic deficit which the world faced at the beginning of the nineteenth century could on this theory only become greater and greater until the whole race of men would be struggling for the insufficient fruits of a niggard earth. But in the very hour when Malthus and John Stuart Mill were most orthodox the theory was being already discredited by a change in the world's production. From an earth which gave too little for the sustenance of her children we have come to a condition where men live in the midst of abundance. We are not so much troubled now by the scarcity of food as by its inadequate distribution. "For the first time in the history of civilization" writes Prince Kropotkin, "mankind has reached a point where the means of satisfying its needs are in excess of the needs themselves."

For untold generations, slaves and peasants and farmers had gotten with pain the barest subsistence from the soil, but, suddenly, as if by magic, two blades of grass began to grow where one had grown before and an acre which had yielded thirty bushels of corn began to give fifty and sixty and a hundred. The area for the cultivation of foods was widely extended by the development of the American continent and exploration and colonization in South America and Africa. New articles of food came into existence. Beets, hitherto but a food for cattle, began to give sugar, and tropical fruits, especially the banana, found their way to every market in the world. The tomato, long suspected of being poisonous and, down to the middle of the nineteenth century, distrusted as a possible forerunner of cancer, has become a food staple. The potato, unknown before the sixteenth century and at the beginning of the eighteenth regarded as a fit food only for swine and

cattle, has assumed the place of chief economic importance among garden products. Twenty-five years ago the European crop of potatoes exceeded in value the entire wheat crop of the world. In the United States in 1912 the increase of potato production over the average of the preceding ten years was 100,000,000 bushels, an additional bushel for every person living within our borders.

A bit of statistics may emphasize the fact of our increasing surplus. The increase of rural population in the United States between 1900 and 1910 was 9 per cent. In the same period the production of wheat increased 31 per cent.; of corn 47 per cent.; of rice 82 per cent.; and the value of all farm property over 200 per cent. Paralleling the rapid advance in agricultural production has been the increase of mineral products. In the decade the production of copper increased 40 per cent.; of zinc 7 per cent.; of iron 69 per cent.; of petroleum 131 per cent.; and of coal 140 per cent. At the same time, the products of manufacture increased far faster than the population. While the latter went forward 21 per cent., the former advanced 84 per cent. How directly this bears on living conditions appears in the fact that the manufacture of food products and textile articles constitute more than a third of the total and show an increase in ten years of 83 per cent. To see how manufacture tends toward the food surplus, one needs but to look at the grocer's shelves. There safely packed away in cans, bottles, cartons, are the seasonal surpluses of widely distant zones. Vegetables, fruits, fish, meats hide behind attractive covers and await the capricious appetites of purchasers. Here one sees also how transportation by rail and boat has eliminated zonal boundaries. Australia, South America, Europe, Asia, and the farthest corners of our own continent are here brought together. The typical American epicure knows no season and no territorial zone. On Christmas day he eats fruits his progenitor of a half century earlier could have had only in June, and in New York he pleases himself with foods available to his ancestors only after ten thousand miles of travel.

To think of a near world famine in the face of these modern wonders of production and distribution is to be disturbed by a dream. The world can now produce more than it can properly consume and the production is increasing at a faster rate than is the population. If there is still hunger in America, it is not due to the scantiness of food. It is due to the inequality of distribution, an inequality, however, that is not static or necessary. We can rest assured that as soon as society has partially recovered its feet after its headlong plunge into wealth, it will set itself to rights and care for every man as he needs. At the present time there are searching efforts being made to ascertain the adequate standard of living for men of various occupations. That that standard will be met out of society's rapidly accumulating surplus is as

sure a conclusion as that the anti-toxin for infantile paralysis will be used when once it is discovered.

One of the surest indications of what this means for the laboring man is the steady increase of estimate of the salary necessary for efficient living. John Mitchell fixed it at $600 for cities of less than one hundred thousand population; Streightoff said $650; the New York State Conference of Charities and Corrections say $825 for a family of five, and the Bruères say $1,200 per annum is the minimum upon which a family of five can maintain an adequate degree of industrial efficiency. The fact that we have come to the place where such standards can be set is an augury of the future of our working people. Involuntary poverty is as sure of elimination as anything in human affairs can be. Time, struggle, courage, patience, individual sacrifice, intelligent handling of the growing surplus, will bring us the new day of economic freedom. With that will be established the real basis of a democratic society, a society in which there will be the possibility of individual distinction coincident with the improvement of the whole state, the two guaranteed by a government in which the sovereign is the whole population.

The period which has seen this reversal of economic conditions is likewise the century of greatest scientific advance. By 1800 Newton had established the law of gravitation; Harvey had discovered the circulation of the blood Linnaeus had developed a biological classification and nomenclature, Buffon had written fifteen volumes of natural history, feeling his way toward a theory of organic evolution, Cavendish had discovered hydrogen, and Priestley, oxygen, while Lavoisier had constructed a chemical nomenclature and discovered the composition of water; surgery had been practised by Hunter and Haller, and physiology and anatomy were subjects of study; Locke, Berkeley, Condillac had originated the doctrine of sensationalism in psychology, and Kant had completed Hume's theory of ideas by denying the possibility of knowing anything beyond the phenomenal world.

Released from the domination of false theology and bad metaphysics, the youthful sciences took mighty steps in the early years of the nineteenth century. Cuvier and Lamarck in biology, Young, La Place, Volta, and Carnot in physics, Dalton in chemistry, were followed a little later by Davy, Faraday, Arago, Ampère, Owen, and a vast army of lesser men. By the middle of the century the pendulum had swung heavily in the direction of biological ideas. Lyell announced the theory of the slow development of the structure of the earth's crust. Johannes Mueller had established the physico-chemical school of physiology, Agassiz had collected many of the facts pointing to the theory of evolution, and in 1859 Darwin published the "Origin of Species." Pasteur discovered the organism known as yeast and the relation of germs to putrefaction.

In 1869 Lister announced his method of antiseptic surgery. Helmholtz had published his "Physiological Optics" in 1866, and in 1879 Wundt, his greatest pupil, had established the psychological laboratory in Leipzig, coincident with the beginnings of experimental psychology by James at Harvard. In the very closing years of the last century and the first decade of the present, physics, which in popular favor had suffered a temporary eclipse by biology and psychology, was revivified by the discoveries of Röntgen and Madame Curie, and now disports itself with a youthful exuberance suggestive of the renaissance, while chemistry and all the sciences allied to medicine engage men and money in a fabulous way. In the field of human affairs, we are attempting to apply the methods of science not only to health, but to education, to industry, and commerce, to marriage, religion and government.

To believe that the great economic change of the last one hundred years and the triumphant march of science have been merely coincident, but not causally connected, would be a great mistake. Without tracing in detail this causal sequence, one can get a vivid idea of the relation of the two phenomena by trying to imagine the result of eliminating science and its achievements from our modern life. Out go the electric light, the gas, the gasoline and the kerosene. Our world which now knows no night is plunged half its time into a darkness relieved only by the flicker of tallow candles and burning wood. The telegraph, telephone, and railroad which have shrivelled this earth into a mere fragment of its former size crumble into ashes, and San Francisco moves away from New York ten times farther than it now is. Ocean steamers become sail boats, distancing London from New York fifty, sixty, seventy days instead of six as at present. Instead of eating foods gathered from the ends of the earth, the average citizen is limited to the products of his own locality and to primitive methods of food preparation. Rapid communication between distant places becomes impossible; books and newspapers, few and expensive; common interests and understanding grow more difficult; illiteracy increases, suspicion arises, popular government over wide areas becomes impracticable, and our twentieth-century civilization a fool's dream.

The consequent shrinkage in the wealth of the world would be enormous, our civilization of a surplus would become one of deficit, every class would suffer retrenchment, but most of all the workers, who, by reason of birth, tradition or other limitations, would feel most keenly the scantiness of the world's supply of material goods.

In this perspective we see how science has worked for the liberation of all classes of society. In the long process of civic emancipation it has finally opened the way for the rise of the man who works with his hands. Nor will the former masters of society be willing to cut short the beneficent results of science, for it adds to the pleasure and efficiency

of the rich and high-born as well as of the poor. But it is to the common man that it means most, for it lifts him for the first time in history above the level of economic slavery. Regardless of all the theories of political science and philosophy, this economic liberation of the fourth estate is working toward the ultimate democratization of society with a force as irresistible as gravitation. It matters little what Bourbon statesmen or scholastics may think about ultimate democracy; it matters tremendously that science has made it possible.

The economic results of science are not its only bearings upon democratic tendencies. Equally important are the changes it has wrought upon the attitude which men take toward the world of things. The time was when it was regarded as the surest way to wisdom to retire from contact with the concrete world of change. Plato held that the supreme duty of man is to escape from the sensible world to the world of ideas. The supreme destiny of the philosopher and his fullest satisfactions are to be found in the life of contemplation, culminating in the vision of the good. The world evident to the senses, the world of observation was thus to be disregarded and neglected. It was instable, changing and altogether below the life of reason. Small need, therefore, to examine it, for through it one would never find the truth, the beauty, or the goodness so necessary for the happy soul.

How large a share this doctrine of Plato's may have had in thwarting the development of science in ancient Greece, it is difficult to see. Mr. Schiller thinks it was very great. There were glimmerings of science and the experimental study of nature in Plato's time. Man was recognized as a part of nature; dissections had been practised by the Pythagoreans; the experimental spirit had expressed itself in the attitude of physicians toward their patients; anatomical research had been extended to animals; the relation of the parts of the body to their functions were discovered; Democritus had glimpsed the essence of atomic physics and had practiced experimental demonstration in his teaching; the relativity of nature to human sensibilities was set forth by Protagorus and other Sophists, and attempts had been made by a score of thinkers to analyze the physical world. But it all came to naught. Through the long night between Democritus and Galileo these flickerings of science slumbered.

To the abortion of these scientific interests several causes probably contributed. But if all the others had been removed, the chief philosophy of the time would probably have prevented any wide application of students to the things of nature, for Plato was the one overpowering genius of his time. The dominance of the Greek philosophy down to modern times is coincident with the sleep of science.

To-day all this is changed; we seek the truth through analysis and mastery of the world of sensible observation. The air, the soil, the

lightning, the slime, the refuse of the world, is yielding up the truth by which we live. Your earlier philosopher would escape from the sensuous world; the modern savant eagerly penetrates its depths, making his implements of research as he goes. Compare Thomas Aquinas in an age which rotted with physical uncleanness withdrawing from the world, exalting divine reason above natural reason and refusing the evidence of his natural reason in order to conserve a difficult faith, with Metchnikoff studying the embryology of sponges, the structure and digestion of polyps, and the blood of water fleas to discover the phagocytes, which mean so much for the preservation of human health and the extension of earthly life. To our scientific minds the slimiest, vilest bit of earth may have the truth we need and will hold it forever locked from him who merely sits and thinks. Because this is so, the whole world of matter has assumed a higher value in our thinking than in any age before. To this exaltation of material things all the advances in evolutionary biology and the studies in physiology and experimental psychology contribute. We see now as not before how much is man of a piece with nature, in his ancestry, in his composition and in his future. And we see that the world of matter in which he lives has much in common with himself. Not to escape this world, but to understand it; not to despise it, but to control it, is our modern aim.

In this altered view of the world and man's relation to it, the man who works with his hands has assumed a new status. Both he and his work are objects of general concern, and manual labor that is skilled takes on dignity and honor with the work of the laboratory. No man who has worked with his hands in any of our modern laboratories will long despise his neighbor whose handiwork is in a shop, or in the cab of a locomotive, grimy as that work may be. This world of ours is fast ceasing to be a world of privilege and war, as it long has been, and is becoming through and through a world of work. Faster than he likes the king is being replaced by the scholar, and the soldier is giving way to the engineer. The province of the priest is suffering encroachment by the physician, and the lawyer is having to recognize the contentions of the social worker. In a score of fields the privilege of dogmatism is being crushed by established facts, and the privilege of contempt must more and more disappear as we see how near akin are all the men who work. In the process of our civilization's making, we see that all who labor must share in the glory of the final achievement. In this new view both the worker and his work are lifted to a more elevated place in our view of things. We realize the human value of the work and we see that through his work the worker himself is made.

A third and more subtle relation between science and democracy consists in this, that they are both unwilling to close the books. Neither can accept a closed scheme of thought. Science can not abide a finished

statement of the world; democracy refuses a static law. In the field of animal behavior it is a fundamental fact that the simpler the exciting situation, the more direct is the response. If there is but one thing to do there is but one needed reaction, but if there are two possibilities of behavior there arise conflict, hesitation and compromise. This condition, present as an elementary fact in the behavior of the lowest animal organisms, reaches up through the whole conduct of man, rendering his life a continual struggle to meet the conflicting and incompatible stimulations of his complex environment. The insistent demand for action leads a man to simplify his world as much as possible. Through a maze of facts and forces he seeks one unitary principle. Every complex situation must be simplified, reduced to its lowest terms. When we do this in chemistry we get the atom; in biology we get the cell; in ethics we get goodness; in religion we get faith.

Wherever men have been thoughtful they have tried to secure a simple unitary formula, not alone for the great departments of life, but for the universe as a whole, including the most distant times and spaces, grouping together into a single system the smallest particle of insensible sand and the most mighty divine being. The Weltanschauung, the total world view, the apparent multiplicity of phenomena lost in the unity of eternal forces, this has been the goal of philosophic thinking. The vision of such a picture stirs and satisfies the needs of men because it gives unity to the world and makes for comfortable thought and conduct. To see the completed picture and then deduce one's own relation to it, gives confidence and security amid confusion. But philosophic vision outruns the logic upon which it would rest, and when once a man has announced such a conception he is compelled to spend the remainder of his days constructing the logic to defend it.

The man who would paint a world picture or construct a closed system of thought finds little encouragement in science or among scientific men. The achievements of science have been in the direction of making the world more multifarious than it was. Instead of water we have hydrogen and oxygen, and instead of a human soul we have a streaming concourse of sensibilities, memories, impulses, thoughts, emotions and decisions. Immersed in the swarming concrete realities of nature, the scientist finds it difficult to discover the single unifying idea. Inasmuch as the progress of research is continually laying bare new realities, he refuses to conclude the case, for the evidence is not all in. He has, besides, a half belief that the most important witnesses may be still in waiting. The things which yet lie hidden may overturn his settled beliefs, as the theory of evolution and the discovery of radium have already done. To the uncovering of these hidden truths all the machinery of his craft is devoted. To enrich the already multitudinous world with discovery of as yet unknown facts and forces is his chief aim.

Not that he does not feel the need of a unified world, but he deprecates a unity with half the world left out. The unity which he seeks must embrace it all. If existent he can not see it. If not existent, it may yet be achieved through his and others' labors.

So also it is with democracy. It holds itself ready to give due justice to hitherto neglected interests. For this reason it does not have the stability so advantageous to interests already recognized and established. If one wishes stable government, he can find it in monarchies better than in democracies. Until within the last short while the Chinese citizen knew far more definitely upon what to depend in the way of future wealth or public office than did the citizen of Ohio. The lineage of his parents and their wealth, and the inescapable doom of sex, prejudiced his whole future within very narrow and definite limitations. For four hundred years the firm grip of Manchurian power, abetted by a religion which emphasized the virtue of tradition and the established order, gave China a government which for stability has seldom been equaled. During the same period the more democratic western peoples have seen turbulence, transition, and constant shift and change of policies.

Nor is the democratic state always the most efficient state. Let the German emperor conceive that the future German Empire is dependent upon particular forms of education and particular humanitarian movements, and he can by virtue of his concentrated power effect the necessary changes in a brief time. The single man can move more swiftly to the achievement of a clearly conceived end than can a whole people be brought up in response to the prophet's vision. It is because of this that Germany in a generation has accomplished industrial, educational, and social changes which would have required much longer if they had been the work of the whole population of the German Empire.

But whatever sacrifice of stability and efficiency must be made the democrat is willing to make in the interest of a larger end. That end is the possibility of forcing to the front interests which the existing government does not recognize. If he wishes to add to his governmental machinery a new instrument, such as preferential primaries, the income tax or universal suffrage, he does not want the way too effectually blocked. Just as men in the sphere of thought refuse to construct a closed system, so do they in the field of government refuse to make their laws and constitutions too rigid, or their public officers too secure in their positions. They want their government fluid and responsive to change, for the moral issues of life are as surely in a process of development as are the intellectual ones. To fix a government on the basis of the moral ideas of 1789 is as repugnant to the man who thinks as to write a natural history in the year 1913 with the theory of evolution left out. Just as certainly as the century has widened our vision of the

world of matter, it has also brought to light moral facts, and problems unknown to the framers of the American constitution. In order that these newer living issues may have their day in court, the democrat is willing to tolerate a less fixed and stable government than is your cavalier, your tory, your man of comfortable surroundings who doesn't like to be disturbed.

Further, we are coming to see that the flexible government is not dangerous, that we may move on to a larger justice easily and smoothly without imperiling the goods we already have. That this new vision is becoming real to us is due to two causes. One of these is our experience in undergoing political changes; the other is our experience with science. Science is not destroyed by new discoveries and inventions. Radium and bacteria may alter certain highly important hypotheses, but they do not destroy our faith in science or make it a less serviceable instrument to men. It has become quite a matter of course to expect revolutionizing discoveries, and science is at heart disposed to readjustment and revision. This attitude has taken hold of the general social mind through the popularization of science, and society at large has acquired a faith in a mobile, growing body of truth. It is probably true that twentieth-century society has no more vital faith than this, and it would be strange if it had not affected our ideas of government and politics.

For the infusion of scientific conceptions into other fields of thought we are not without splendid precedent. President Wilson has shown how the American constitution was a reflection of the prevailing Newtonian physics, and all of us know how thoroughly the concept of evolution has interwoven itself into every specialized department of modern thought. In like manner, the growing receptivity of men's minds to new interests in society, to the rights of the laboring classes, to the claims of dependent peoples, to the widening interests of women and children, has been greatly accelerated by the diffusion of science and scientific ways of thinking. Men have become accustomed to changing their minds, to having their beliefs unsettled, to feeling the good that comes with a new order of things.

Finally, and in the most subtly penetrative way, the kinship of science and democracy appears in their attitude toward the future. To both, the present is but a cross section of an advancing stream whose source is in a distant and indefinite past, whose current has gathered momentum in its progress hitherward and which is pouring itself into the future with a rapidly accelerating force. To neither is the past of this stream so interesting or important as its future, and the present is but a point of vantage for the movement forward. There is a type of mind to whom this way of thinking is difficult or even offensive. To it the good things were the possession of former peoples, and to those

earlier wisdoms and virtues the modern reprobate may hardly attain. Such is the theological mind, whose vision of the truth is a distant and completed revelation; such is the legal mind which judges a current moral problem wholly by the legal precedents. The one hallows the ten commandments; the other glorifies the constitution. Of such mind are we all when we uncritically accept the conventions of our group or yield thoughtless obedience to the traditions of our race. To capitulate to custom or resign ourselves to habit is to accept the past as virtuous and final.

Against this view of the world both science and democracy resolutely oppose an exuberant faith. The bulk of men is wiser and better than it has ever been; it can be infinitely better and wiser than it is. The critics of science have gratified themselves in pointing out the limitations of its method. But science replies by pushing those limitations further back. The whole achievement of experimental psychology has been made against the settled belief on the part of many that it could not be done. Twenty years ago it seemed that physics had finished its task. There was then a pessimistic feeling that all the interesting things had been discovered. To-day men are undertaking experiments that would have been thought fantastic at that time, and the undiscovered territory seems greater than ever. They said we could not fly, but Professor Langley and the Wright Brothers did it. They said you can not predict the weather, but we can tell it a week ahead of time. Once it was thought a miracle to cure the blind, but now we do it every day. Once disease was regarded as the visitation of an offended god, but to-day we meet it and destroy it with the instruments of science. Once insanity was the evidence of evil spirits, but to-day the legion of devils is put to flight by medicine and psychology. Once marriage was regarded as a holy ordinance to be approached in the spirit of religious humility; to-day its holiness depends in part upon its religious sanctions; it also depends upon its effects upon possible posterity as these are indicated by biology and pathology.

Nor is your individual scientist confused or disheartened when you point out to him how science fails in hosts of cases. He knows that aviators fall, that the weather does not turn out as predicted, that there are far more diseases for which we do not know the cure than there are of those for which we have an antitoxin, that there are forms of insanity that are supposedly incurable, that we do not know all the laws of heredity, that the subtle processes of human thinking and education are baffling to our present psychological methods. But he is not a pessimist. He is one of an advancing army, and he believes that all about him there are the solid achievements of the campaign; points have been taken and citadels have been established back of which the forces of science will never need to retreat. That many of the supposed con-

quests of science have been found unsound and that the still unpossessed territory is illimitably greater than that already gained is but a challenge to his courage and his resources. To the truly scientific spirit science is in part an achievement; in a larger sense it is a hope, an aspiration, a kind of intellectual idealism. As prophecy it is more convincing than revelation; as a field for constructive imagination it is as interesting as poetry or music.

This also is the spirit of democracy. If one insists on regarding society as a completed thing, then it must be admitted that democracy does not justify itself. It has never yet established on a lasting basis that thoroughgoing equality of which it dreams. The so-called democracy of Greece was admittedly founded upon the institution of slavery; that of England rests upon an economic submergence of large masses of its people, and in our own country privilege in business, politics, education and religion, with the consequent corruption of society and abortion of justice mocks our praise of democracy even while we make it. Our enemies need but to uncover the facts to lay bare a frightful indictment of our claim that democracy is the best form of social organization. City councils bought with money, weak and incompetent mayors, police forces subdued by threats or seduced by gifts, legislatures the willing servants of men who want the law shaped for their private gain, governors caught in the clutches of the party machine and unable to perform their sworn duty as executors of the law, seats in the senate bought with money or the promises of preferment, retired congressmen delivering their information acquired in the public service to private wealth for private ends, public courts shaping their procedure so that the man of means has an advantage over the poor man in the administration of justice, the supreme court of the land erecting itself into a law-making body through constitutional interpretation and thereby overriding the wishes of the people as expressed through their legislatures; four million laboring men subsisting on incomes below the level of a living wage; children sacrificed to factory labor; women unable to secure from state legislatures labor conditions comparable to those of men; the dispensation of religion administered in such a way as to make the rich comfortable and stupid, the poor indifferent or bitter, and the thoughtful anti-ecclesiastic; education for the professional classes but little for laborers; palaces and leisure for the rich and hovels and drudgery for the poor these are the facts flaunted before us in this most democratic country in the world.

But the real democrat is not disheartened by the hideous picture. He sees all this and he sees beyond it. In the presence of many failures he discerns one success, and to him that success is the important thing. You show him a score of corrupted cities, and beyond them he sees Cleveland with its new charter; you show him the terrible conditions

of the textile and steel workers and he thinks of the workmen's compensation and state insurance laws; you show him a score of state governors subservient to the pressure of wealth and he recalls Johnson and La Follette; you show him failures in government ownership and he thinks of the post office and Panama Canal; you talk of aristocratic churches and he remembers the Salvation Army and the institutional church; you mention subsidized education, and he thinks of the state university; you recount the multitudinous cases where the popular suffrage fails to select men of learning and character and he thinks of Hughes, Roosevelt and Wilson.

That the upward strivings of democracy should have issued in innumerable abortions of social ideals is what on his theory was to have been expected. That these same strivings should have brought to maturity one well-born child of promise is much more significant, for it is the augury of the future. Not the level of his attainment but the direction of his going, concerns him most. His faith in democracy is not a doctrine of comfort; it is one of effort; he believes not so much in something attained as in something attainable. It is not something to be preserved, but something to be achieved. Just as science is an intellectual aspiration, democracy is a moral aspiration. Together they constitute an idealism toward which the will to live strives with an ever-increasing measure of success. To get the tinge of this idealism is to have one's fragmentary work become more vital. The isolated research and the little extension of justice in the affairs of men become significant by their association with larger movements. These in turn grow weighty with the wider purposes of many men and distant times.

In the realist sense, therefore, our modern life is typified by the twin movements of science and democracy. To our aspirations they give hope; to their achievement they solicit all that is vital and generous in men. They front the future not with the fatalistic view that somehow all will turn out well, but with the settled faith that that future will be made by what men do. Both are militant movements. They set a world of problems still unsolved and lay upon men the obligation to find the way. In their behalf they enlist a number of social forces, but to be the leader in their militant campaigns the call comes loudest to the university. Sad will it be if its ears are closed with selfish pursuits or its feet heavy with an unforgettable past.

BIOLOGICAL EFFECTS OF RACE MOVEMENTS

By Chancellor DAVID STARR JORDAN

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THERE are but three ways in which the force of a race or a nation may be permanently lowered: (1) Emigration, the transfer of stronger elements to other regions; (2) immigration, filling up the gaps with people of lower native ability or energy; (3) war, the destruction of the virile and soldierly.

Emigration has played a large part in the depletion of peoples in different districts of Europe and even in older sections of the United States. This may mark a loss to the particular region involved, but none to the world, the value of a man and his posterity, broadly speaking, being as great in one place as in another. Moreover, the pioneer gains by travel, picking up something on the road, though he may also lose through separation from the framework of society. In the new freedom he tends to fall out of touch with the achievements of the old social fabric. Much of human effectiveness consists in entering into the work of others. But, on the other hand, the pioneer will escape many hampering traditions, and the sturdiness of racial stock is in no way dependent upon culture, the social values of native strength reasserting themselves when opportunity offers. Meanwhile, the gains in the new world may be traced as losses in the old. For example, from the counties of Devon and Somerset arose, primarily, the colony of Massachusetts Bay. From the loins of Old England, New England arose, and from self-governing New England, the democracy of the United States. From Devon especially came forth the Puritan conscience, most precious political heritage of the republic. Under its influence every public act finds its final test in moral standards. Such standards still rank more highly in America than in any other land. The American people may consent to unrighteous deeds under the impulse of falsehood or greed, but only for a time. They make many mistakes in the rush of events. They may apply standards wrongly, but, if they do, the case comes up again for settlement until at last it is settled rightly.

By *immigration,* lands scantily occupied by barbarous races have been replaced by peoples more efficient or more aggressive. Through the same agency strong nations have sucked in weaker groups to fill the vacuum caused by war or to meet the demands of industry. The history of America, North and South, has furnished examples of all these. Through conquest by war as well as out of industrial needs grew up the

institution of slavery. In Rome, "whole tribes were borrowed" for the work of agriculture, while conquered groups were utilized as menials or slaves.

Everywhere, under these conditions, the blood of the slave or the conquered has diluted that of the dominating race, usually to its detriment. For example, in most Spanish and Portuguese colonies Latin blood has been mixed with the aboriginal, producing crosses showing few of the virtues of the European stock. Indeed, in Portugal, the mixture from subject races in Brazil, Africa and India, has invaded the parent itself to its social and political confusion.

Two main facts appear in this connection. In many racial crossings occurs the mingling of the least desirable types of each. Naturally where the dregs of one race mix with the offscourings of another arise distressing possibilities of vice and incompetence. For instance, the Eurasian in Asiatic sea-ports "is damned from his birth and on both sides." But when good European blood mingles with Asiatic strains as good, there is no evidence that the progeny is inferior to either parent stock.

The words "hybrid" or "mongrel," terms of reproach as usually applied to the human race, relate commonly to the union of widely different peoples. But the question of "race or mongrel" can not be settled by *a priori* assertions as to superiority of pure over mixed races. There is no general law that mongrels are sterile, inert and non-resistant. It is a matter to be determined in any individual case of crossing by a study of the results derived. Experiments of the sort have no pertinency unless best is mated with best, and even then they might prove conclusive only if many times repeated. And no result shown in individuals need be valid as a general law of crossing. It would apply only to the particular types in question. No important information could be expected from the study of the first generation. One would need to know the nature of the recessive characters involved as well as of the dominant ones. The final Mendelian disposition of mixed race characters must determine the final answer.

The intermarriage of European races can hardly be called crossing at all, as the racial differences concerned are of slight order, little more than temperamental at the best, and most of the traits we commonly recognize are matters of education. All those qualities which disappear in a generation in America must be chargeable to education, not to race. And, in general, other things being equal, the advantage seems to be on the side of the blended races which belong to the same general stock. Moreover, in civilized lands, there are only blended races. Blending is part of civilization. Pure strains confined to isolated islands or valleys, thus withdrawn from competition, by no means represent the best of any race. There is no wide-spread race which is pure. There is no such

thing as a pure-blooded German or Frenchman. "Norman and Saxon and Dane are we" of England. Likewise are we Briton and Welsh and Cornish; also Scotchmen, Highland and Lowland, Manxmen, Ulstermen and Irishmen.

That the crossing of the closely allied European races in America has, of itself, brought no disaster to our republic is a matter of visible observation. That wide crosses necessarily work always for evil is not proved. Apparently the mulatto in America, as a whole, is superior to the pure African negro. And the ultimate fate of the negro race in America is apparently to become mulatto, even though the introduction of white blood is relatively much less frequent now than in the days of slavery. But, in all these matters, we are much in need of scientific, that is, exact and systematized information.

However, it can be clearly seen that the introduction of black blood has not been a gain to the republic. And we may also admit that much of our later immigration from Europe and Asia has lowered our own average. The original impulse to America was that of escape from paternalism and oppression, two words for the same thing. America was a haven of refuge from senseless tyranny. Immigration thus brought to the new world a wealth of initiative and adaptability, such as no nation ever inherited before. But in later days this current has changed. Wider opportunity has opened before the common man in the more progressive nations, and the incentive of freedom has been less acute. Moreover, while still "America means opportunity," this is not always to be had for the asking.

The demands of manufacturers, the operations of steamship companies and the possibilities of earning money without economic freedom, and later, the ruinous cost of war are drawing another type of immigrant from other parts of the world. Among the immigrants of to-day there are some with magnificent personal possibilities, men of the stuff that makes republics. But most of them are not such, and, while their presence adds to our material wealth, they constitute, as a whole, a burden on our democracy. Only a man who can take care of himself and have something left over for the common welfare is a good citizen. It is hard to maintain the principle of equality before the law among people who have never felt and never demanded such equality.

The claim is sometimes made on an assumed basis of science, that all races of men are biologically equal, and that the differences of capacity which appear are due to opportunity and to education. But opportunity has come to no race as a gift. By effort it has created its own environment. Powerful strains make their own opportunity. The progress of each race has depended on its own inherent qualities. There has been no other leverage. Physical surroundings have played only a minor part. To say that one race as a whole is inferior to another is only to

repeat what is said every day by individual men. This does not imply that the lower man or the lower race need be robbed, enslaved or exterminated. Nor that a lower race may not produce its own prophets or scholars or heroes. The tribe of Australian bushmen is counted one of the lowest on earth. Not long ago I met in Adelaide, a full-blooded "Black-fellow," broad-minded and competent, a mechanical engineer by profession, a man who would hold his own in any community. That race is lowest which shows, on the whole, least capacity for self-elevation. "All men are born free and equal," it is asserted, but such equality is political only. It can not be biological. In every race are certain strains having capacities not attainable by the mass. There should be equality of start, equality before the law, but there will always be differences of attainment. The gifts of potentiality, unit characters of the germ-plasm, are not shared by all people of the same race. The average status of one may be below that of another, and the highest possibilities of one type may be greater than that of another. In general, the highest range of possibilities in every field has been reached by the "blonde races" of Europe. Groups of less individual or of less aggregate achievement may properly be regarded as "lower."

NATURAL SCIENCE IN THE MIDDLE AGES

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PROBABLY ninety-nine out of every hundred educated persons would be surprised to learn that there was any such thing as natural science in the middle ages. Lest I seem to impute too much ignorance to my present audience, perhaps I should lower the ratio to nine persons out of ten. That is really a flattering estimate, since one of the most recent works on the middle ages, Taylor's "The Medieval Mind," while it devotes two volumes to monasticism, scholasticism and other features of medieval thought, treats of natural science in the middle ages only incidentally in two chapters upon Albertus Magnus and Roger Bacon, and dismisses all other medieval students of nature with the words,

> Assuredly, through all the middle ages there were men who noticed such physical phenomena as bore upon their lives, even men who cared for the dumb beginnings of what eventually might lead to natural science. But they were not representative of their epoch's master energies.

Such an attitude is due partly to the fact that the history of science has as yet been little investigated; it is also partly due to misconceptions concerning the middle ages. If we appreciate what the middle ages really were, we shall not be amazed to find an interest in natural science then.

Every one knows that by the term "middle ages" is roughly indicated the period between ancient civilization and modern civilization, or, more specifically, between the decline of the Roman Empire and the Italian Renaissance or the discovery of America. For a time historians, under the influence either of classical or of Protestant prejudices, seemed to think that between ancient civilization and modern civilization there was no civilization. Therefore, the term "dark ages" was applied to the middle ages. Everything worth while in modern life was supposed either to have been rescued from the ruins of antiquity by the men of the Renaissance, or to have originated at some time since. Every disused and decadent idea or custom which modern men threw away on to the historical ash-heap was designated as medieval.

But after a while the middle ages were studied more thoroughly and sympathetically. Monasticism, feudalism, scholasticism, the social and

industrial groups of manor and guild, the crusades, the pilgrimages, the friars, the cathedrals, and the great ideals of the church and of chivalry, were recognized as important in human history, though different from the thoughts and doings of men before or since. The expression "medieval civilization" was now introduced alongside of "ancient civilization" and "modern civilization," while the phrase "dark ages" was restricted to the early middle ages while the barbarian invasions were going on. Indeed, a recent writer on the history of education wittily states that successive investigations keep pushing the "dark ages" so much further and further back that they will probably ultimately cover no time whatever.

There was, then, civilization, if not natural science, in the middle ages. But it would be leaving a wrong impression to imply that medieval civilization was something quite distinct from ancient or modern civilization. The fact is, and after all it is just what one would naturally expect, that medieval civilization was in large measure a combination of ancient and modern elements. Much it inherited; much it originated; and much it passed on. Moreover, the middle ages really belong partly to ancient and partly to modern times. This principle is now being largely accepted even in high-school teaching and text-books. The year course in ancient history is carried down to Charlemagne, while medieval and modern history are united as a single year's work. In the museums of Europe, too, no great gap is observed between the middle ages and the renaissance, but objects are usually classified together under one caption as of both those periods.

It is very difficult to separate history into distinct periods, yet there is considerable reason for regarding Charlemagne, towering as he did seven feet tall and fighting a campaign every season for over forty years, as the last great landmark of ancient times. With all his vigor he caused little or no permanent progress. He failed to drive the Mohammedans from Spain; under his successors the Northmen and other invaders broke up his empire. But when the Northmen, after their wonderful expansion in all directions from Greenland to the Mediterranean and from Russia to North America, had settled down in Normandy, England, Sicily and elsewhere; when they had with amazing rapidity adapted and improved upon such civilization as they found still existing in their new homes; when the Arabs had brought from the East to Spain the material civilization of the Orient and the intellectual treasures of the Greek genius; and when the men of the north, either as peaceful traders and pilgrims or warlike crusaders, had visited Spain, Constantinople and the Holy Land; the wheels of progress started moving with a new alacrity and things began to hum. Once again, as had happened before in the Mediterranean Basin, the races of the north descended upon and fused with those of the south, and the east passed on to the west the torch of civilization.

The results of this contact were felt first in Spain and Italy, but the new civilization became generally manifest throughout western Europe in the twelfth and thirteenth centuries. This is the period of which I shall speak this afternoon, and I shall now remind you of some things in the twelfth and thirteenth centuries that were modern in character, so that you may not be surprised when I suggest that modern science, too, began in the middle ages. A book has been written recently on what we owe to the Greeks; let us see what we owe to the middle ages.

In the first place, the Celtic and Teutonic races and the Roman Catholic church. Those races were absorbed, and were trained and inspired to erect a new civilization. In this work the church, as the greatest social force of the times, played the chief part. It has well been said that the Teutonic vigor and originality, and the spirit of western Christianity were quite as responsible for the Italian Renaissance as was the classical revival. There was no renaissance at Constantinople, though there was plenty of study of Greek there. At Constantinople classical culture remained as it were in cold storage. In Italy there was a fresh living movement. New blood and new ideals were responsible.

Secondly and more specifically, our modern languages and literatures began in the middle ages before the classical revival. Already in the twelfth and thirteenth centuries the languages of modern Europe were taking on literary form, and poets were expressing in their own tongues the spirit of a new age. A specialist in comparative literature assures us that the popular literature of the twelfth and thirteenth centuries resembles eighteenth and nineteenth century literature more than it does that of the ninth and tenth centuries which were so much nearer in mere point of time.

In art we owe to the middle ages the marvelous Gothic style of architecture with its new structural conceptions and infinite resource of adornment.

In politics there began then national states in contrast to the city states and empires of antiquity. Representative government, too, was developed as it had not been in ancient times. Representative institutions were widespread in western Europe at the close of the thirteenth century, and survived in England through succeeding centuries to furnish a model for other nations which reintroduced parliamentary government in the nineteenth century. Bishop Stubbs limited his famous "Constitutional History of England" to the medieval period. During that time the English were busy making their constitution; ever since they have been busy breaking it.

The middle ages recovered from the economic dry-rot which had ruined the Roman empire from within before ever the barbarians broke through its military shell from without. The middle ages revived the

city life of antiquity, but with these modern differences, that religion was separate from the state, and that the institution of human slavery found no place in the medieval town. There the freeman was not ashamed to toil, and the runaway serf could acquire liberty. Slavery has been reckoned by one historian of science as one of the five great obstacles to the advance of science in antiquity; if so, the middle ages were better off in this respect.

Early in the twelfth century there was a great outburst of enthusiasm for learning and of intellectual curiosity. Students swarmed from all parts of western Europe seeking teachers; the result was that foundation of the European universities whose intellectual life has been continuous from then until now. Roman law was revived and studied scientifically. The fruits of Greek philosophy, preserved by the Arabs in Spain or the Orient in translations and commentaries, were translated again,—this time into Latin, which in the Christian West was now the universal language of scholarship. Humanism, classical scholarship in the strict and narrow sense, and the great paintings and sculptures of the Italians in the fifteenth and early sixteenth centuries, were but later phases of the same movement. Petrarch, the first great humanist, who adored Cicero, wrote letters like Pliny the Younger, collected and copied ancient manuscripts, and came to scorn all contemporary interests except his own fame, has often been called the first modern man, but in many ways seems a reactionary looking backward. Abelard, the first great schoolman, who over two centuries before Petrarch's time wandered forth from his native Brittany, first seeking teachers, then triumphing over them, then attracting students to himself; Abelard, who dared to show that even the church fathers held conflicting opinions, and who advocated sceptical and systematic criticism as the best road to knowledge; Abelard, more than Petrarch, deserves the title of the first modern man.

Turning now from medieval civilization as a whole to this medieval learning in particular, let us correct some erroneous notions concerning it. For one thing, we have been taught to call medieval learning scholasticism, and to think of it as concerned almost exclusively with logic, metaphysics and theology; while we have been taught to associate the beginnings of modern science with the Italian Renaissance. But the fact is that the narrow humanist of the Renaissance took no more interest in natural science than did the narrow schoolman of the middle ages. The sciences which they cultivated were philology and theology. The fact is that natural science has had a more or less continuous development of its own, largely independent of the middle ages and Renaissance. Books on nature written in the twelfth and thirteenth centuries were still satisfactory to readers in the fifteenth and sixteenth centuries, as is shown by numerous editions of them which were printed then.

The reliance of the middle ages upon the authority of the Greek

philosopher Aristotle has often been exaggerated. In medicine they recognized Galen as a greater authority than Aristotle. In astronomy Ptolemy was their guide. In natural history they cited Pliny the Elder. Indeed they used scores of other authorities than Aristotle. But had he been their sole source of information, they would not have been without interest in natural science, for Aristotle devotes much attention to that field. He wrote not only on logic, ethics and metaphysics; but on physics, animals, plants, minerals, the heavens, sleep and waking, generation and corruption, and so forth. Indeed, he was without much doubt the greatest scientist of antiquity.

Now the twelfth century had known only Aristotle's "Logic." When his other works were brought from Spain and translated from Arabic into Latin in the early thirteenth century, those devoted to nature created even more of a *furore* than the others. The great University of Paris at first prohibited these newly discovered books in natural philosophy. But it was impossible to check the rising tide of secular and scientific learning. Another French university at Toulouse advertised its readiness to teach these works of Aristotle on nature, and before long the forbidden books were being freely taught at Paris itself.

Paris's two leading theologians and commentators on Aristotle were also recognized in their own day as great students of nature. Albertus Magnus wrote on all the subjects that Aristotle had treated and added much new information in his works on plants and animals. Thomas Aquinas is usually thought of as a theologian; but when he died, the University of Paris wrote to the Dominicans asking that his bones might be sent to Paris for burial, and also requesting the transmission of some books begun by him while at the university but not as yet completed upon his departure from Paris. What were these writings; theological treatises, commentaries on the minor prophets, or manuals of devotion? None of these. They were a commentary on the philosopher Simplicius; another on Aristotle's treatise "The Sky and Universe"; a third on Plato's "Timæus," a dialogue dealing with nature; and finally, a treatise on irrigation and mechanical engineering.

Another erroneous notion concerning the middle ages is that nature was studied chiefly in order to illustrate spiritual truth or to teach moral lessons. The "Bestiary," a little manual about animals used by the clergy for illustrations in their sermons, is often referred to as typical of medieval science; but one might as well judge modern science by the lurid articles in the supplements of our Sunday newspapers. Far more typical are the long encyclopedias in Latin prose which collected all available information concerning the phenomena of nature, and whose motive was rather a keen curiosity about the things of this world than a desire merely to illustrate divine verities. It is true that one of the earliest and briefest of these encyclopedists, Alexander Neckam, an

English monk, still tends to moralize and allegorize. For instance, he says that some persons call the spots on the moon caverns or mountains, but that he believes that they were put there to signify the stain of sin which Adam's transgression brought into the world. But Neckam also displays a scientific attitude. When he finds a statement in the book of Genesis in apparent contradiction to the astronomy of his time, he explains that the Bible here follows "the judgment of the eye and the popular notion," but that astronomy is really right. The later and longer encyclopedias of Arnold of Saxony, Thomas of Cantimprè, Bartholomew of England, and Vincent of Beauvais greatly increased the amount of space devoted to nature and contained comparatively little moralizing.

I may explain that in a medieval encyclopedia, instead of the alphabetical arrangement followed in modern encyclopedias, there is first a topical arrangement under such heads as Reptiles or Birds or Trees, and then an alphabetical arrangement under each topic. As in modern encyclopedias, most of the information was taken from other books, but sometimes the medieval encyclopedist adds new data which he has heard from hunters, travelers and others, or which he has learned from personal observation.

The twelfth and thirteenth centuries were a period of intellectual curiosity. Albertus Magnus says that he lists the properties of individual plants in order to satisfy the curiosity of his students. A favorite book of the period, translated into almost every European language, was entitled, "De omni re scibili et quibusdam aliis" which may be freely translated as "Concerning everything that can be known and then some." Indeed, it is not merely in professedly learned works written in Latin that one sees the interest of those times in natural science. If we turn to popular literature in the tongue of the layman and open one of the long French romances of the thirteenth century, we find Dame Nature making a speech concerning various branches of natural science which occupies a considerable section of the entire poem, whereas little space is devoted to logic or theology.

This interest in nature is often accompanied by an independent scientific spirit, of which we have just seen some evidence even in the moralizing Neckam. But it can be traced back earlier than him to the beginning of the twelfth century. As the life story and writings of Abelard illustrate the great interest in logic, philosophy and theology at the beginning of the twelfth century, and help to explain the origin of the University of Paris; so the career and books of a contemporary of his with a very similar name, Adelard of Bath, depict a pioneer of natural science. As Abelard went forth from Brittany through the towns of France in quest of Christian teachers, so from England Adelard made a wider circuit in lands both Christian and Mohammedan, where he might acquaint himself with all that was best in contemporary learning, but especially in mathematics and natural science.

In one of his works he tells us that upon his recent return to England after long study abroad, his nephew and other friends urged him to disclose some of the new ideas that he had learned among the Arabs. The result is his treatise called "Natural Questions" in the form of a dialogue with his nephew, who proposes, by means of a set of questions, to force his uncle Adelard to justify his preference for "the opinions of the Saracens" concerning nature over those of "the schools of Gaul" where the nephew has been studying. Adelard agrees to this, but wishes to state at the start that, because of the prejudice of the present generation against any *modern* discoveries, he will attribute even his own ideas to the Arabs and will not be personally responsible for what he says. "For I know," he declares, "what misfortunes pursue the professors of truth among the common crowd. Therefore it is the cause of the Arabs that I plead, not my own."

Adelard's use of the word "modern" should be noted. The word *modernus* is not found in classical Latin, but is often employed in the twelfth and thirteenth centuries. In another passage Adelard distinguishes "the writings of men of old" from "the science of moderns." Bartholomew of England rejects an astronomical theory of the Venerable Bede, and says that he prefers the view of "modern writers who, as I think, have scrutinized the subtler signs of philosophy more profoundly." Peter of Spain, who finally became Pope John XXI., in one of his medical treatises states his sources of information as "ancient philosophers" and "modern experimenters." Several other writers use like expressions. So perhaps Adelard rather than either Petrarch or Abelard should be called the first modern man.

The opening question asked of Adelard by his nephew is, "How can plants grow from earth which they so little resemble?" The nephew fails to see how this can be explained except as "a marvelous effect of the marvelous divine will." Adelard retorts that no doubt it is the Creator's will, but that the operation is also not without a natural reason. This gives a fair example of the tone of the dialogue throughout; Adelard upholds scientific argument and investigation against a narrow religious attitude. He insists that he is in no way detracting from God, whom he grants to be the source of all things, but that nature "is not confused and without system," and that "human science should be given a hearing on those points which it has covered." He also sets reason above authority; and sharply reprimands his nephew for following authority as if he were a brute led by a halter, for his bestial credulity, for his trusting simply in the mention of an old title. In fine, he tells his nephew that if their discussion is to go any further, he must drop authorities and "give and take reason." He assures his young relation that he is not the sort of a man "who can be fed on the picture of a beefsteak."

It is true that both questions and answers in this pioneer book of natural science are usually more amusing than instructive to the modern reader, although Adelard in his prologue says that he is sure his treatise will be useful to his hearers, but not that it will prove entertaining (tractatum . . . quem quidem auditoribus suis utilem fore scio, iocundum nescio). Asked why men do not have horns, Adelard first objects that the question is trivial; but when the nephew urges the utility of horns as weapons of defense, Adelard replies that man has reason instead of horns, and that, as a social as well as bellicose animal, he requires arms which he can lay aside in time of peace. Asked why the nose is placed above the mouth, he replies that it serves the head while the mouth serves the stomach. Many of his explanations are grounded upon the hypothesis current since the Greek philosopher Empedocles, that all nature is composed of four elements, earth, air, fire and water, and characterized by four qualities, hot, cold, dry and moist. Thus when Adelard is asked why bright students often have poor memories, he answers that a moist brain is conducive to intelligence, and a dry cerebrum to memory. He explains his nephew's weeping for joy to see his uncle safely returned from the Orient by the theory that his excessive delight heated his brain and distilled moisture thence.

But reasoning from a general theory of nature to explain particular phenomena is not Adelard's sole method; he also relies on experience. Nor are all his notions crude and incorrect. While he accepts the long established theory of four elements, he is careful to explain that the earth which we see and call by that name is not the element earth, and that no one has ever touched the element water, or seen the elements fire and air. Every particular object contains all four elements, and in daily life we deal only with compounds.

Adelard states the eternity of matter as follows:

> And certainly in my judgment nothing in this sensible world ever perishes or is less to-day than when it was created. If a part is dissolved from one union, it does not perish but is joined to some other group.

When his nephew asks him to explain the working of a magic water jar which they once saw at an enchantress's house, and which had holes in both top and bottom so that the attendant could check the flow of water from the bottom by placing his fingers over the apertures in the top, Adelard accounts for the trick by saying that nature abhors a vacuum. Asked how far a stone would fall, if it were dropped into a hole which extended through the center of the earth, he states that it would fall as far as the center and stop there.

We have heard Adelard upholding scientific argument and investigation against a narrow religious attitude. This position is further illustrated by a contemporary of his, William of Conches in Normandy. William, too, complains that the age is instinctively hostile to new

ideas; and dilates upon the unreasonableness of those persons who are unwilling to listen to explanations of the natural phenomena mentioned in the Scriptures, but prefer to accept them blindly. He declares that since they themselves know nothing of the forces of nature, they are unwilling that any one else should investigate these. "We, on the contrary," he says, "think that a reason should be sought in every case, if one can be found." In another passage William's indignation is aroused by those who say, "We don't know how this is, but we know that God can do it." "You poor fools," he retorts, "God can make a cow out of a tree but has he ever done so?"

This theological opposition, of which Adelard and William are conscious, brings before us the important problem of the attitude of the medieval church to science. There is not time to-day to argue it at length; I can only give you my conclusions. We see science establishing its own standpoint and marking out the boundaries of its realm. The first surveyors, like Adelard and William, naturally meet with opposition and encounter a jealous attitude which fears lest study of science and nature will be at the expense of religion and God. But in the end it turns out that so long as they do not trespass upon the particular preserves of theology their stakes are not pulled up. In the course of two centuries the church gradually gets used to science, just as the University of Paris finally accepts the new Aristotle. By the middle of the thirteenth century Thomas Aquinas, from whom we expect an authoritative presentation of the position of the church, holds that to a large extent the fields of theology and natural science are distinct; that theologians should not try to settle purely philosophical or scientific problems, and, conversely, that every theory of ancient philosophy or scientific hypothesis is not to be regarded as a religious dogma.

Men of science, who were often clergymen themselves, seldom attacked Christianity in the middle ages, and as a rule maintain the usual medieval tone of respectful and devout feeling toward theology and religion. Conversely, there seems no adequate proof for a single specific instance of persecution of men of science by the church for purely scientific views in the twelfth and thirteenth centuries. The occasions when such men got into trouble and when we know the reason why, are just those occasions when they left science to dabble in theological or ecclesiastical concerns. Roger Bacon has often been pictured as a long-suffering martyr to the cause of science, but this is a legend constructed from historians' imaginations and added to by successive writers; the sources indicate that he was imprisoned only once, and then we do not know for how long nor whether his scientific work had anything to do with it. On the other hand, many cases might be mentioned where popes and prelates patronized and protected medieval men of science, while Peter of Spain became pope himself.

It can not be shown then that there was bitter warfare between science and theology in the middle ages; nor, on the other hand, was science a handmaid at theology's beck and call. The two interests were beginning to separate, sometimes with a little friction, often with much caution on the part of science, yet on the whole with maintenance of friendly relations between them. Science was still somewhat under the wing of the church, but science was learning to use its own wings.

Having traced back the scientific spirit in western Christian Europe to the twelfth and thirteenth centuries rather than to the time of the Italian Renaissance, let us now examine some of the particular fields which it investigated.

Physics was studied now, and not merely along the theoretical lines of Aristotle's treatise. Further progress had been made among the Arabs in optics; and the subjects of vision, perspective, reflection and refraction were now better understood than in the time of Ptolemy. The men of the thirteenth century speedily absorbed these new ideas of the Arabs. Roger Bacon, it is true, while according due credit to the Arabs, gives us the impression that his Latin contemporaries were neglecting the subject of optics, and describes the formation of rainbows, and the characteristics of convex and concave mirrors, burning glasses and lenses by which the size of objects can be greatly magnified, or mirrors by which their numbers can be greatly multiplied, as if all these things were marvelous novelties. Bacon's own discussion of these matters is excellent, and in some details he corrects or adds to his Arabian authorities, but he does not do justice to his Christian contemporaries. At just about this time Witelo, a Pole who traveled in Italy, wrote an important treatise on optics in which he embodied the views of Alhazen, the leading Arabian authority, together with many additions from other writers and of his own. Moreover, the French "Romance of the Rose," probably written soon after Bacon's work, shows remarkable familiarity with all the things that he describes. Of rainbows it remarks that

> Only he who's learned the rule
> Of optics in some famous school
> Can to his fellow men explain
> How 'tis that from the sun they gain
> Their glorious hues.

The author also mentions burning-glasses and various other sorts of mirrors, but he refers to all these as well-known scientific facts, and says that there are plenty of books about them. He also unmistakably describes magnifyng glasses when he tells us that from optics one

> . . . may learn the cause
> Why mirrors, through some subtle laws
> Have power to objects seen therein
> (Atoms minute or letters thin)
> To give appearance of fair size,

Though naked unassisted eyes
Can scarce perceive them. Grains of sand
Seem stones when through these glasses scanned.

The poet goes on to say that through these glasses one can read letters from such a distance that one would not believe it unless he had seen it. Then he concludes,

But to these matters blind affiance
No man need give; they're proved by science.

From the testimony of several other contemporaries we know that eye-glasses had been invented before the close of the thirteenth century.

Another important physical treatise besides Witelo's was a "Book on Weights" by Jordanus Nemorarius earlier in the century. In this work he is said to have made progress in dynamics beyond the ancients. Another invention of great use to science, clocks, was worked out during the middle ages. An innovation of great convenience in scientific reckoning and records was made when Leonardo, a merchant of Pisa, in a work written first in 1202 and then revised in 1228, brought the so-called Arabic numerals to the attention of Western Europe. Some progress in algebra was also made in the middle ages, and Roger Bacon emphasized the importance of mathematical method in scientific investigation.

It can not be shown that Roger Bacon actually anticipated any of our modern inventions, but the following passage from one of his works does indicate that an interest existed then in machinery and mechanical devices, and that men were already beginning to struggle with the problems which have recently been solved.

Machines for navigation can be made without rowers so that the largest ships on rivers or seas will be moved by a single man in charge with greater velocity than if they were full of men. Also cars can be made so that without animals they will move with unbelievable rapidity; such we opine were the scythe-bearing chariots with which the men of old fought. Also flying machines can be constructed so that a man sits in the midst of the machine revolving some engine by which artificial wings are made to beat the air like a flying bird. Also a machine small in size for raising or lowering enormous weights, than which nothing is more useful in emergencies. For by a machine three fingers high and wide and of less size a man could free himself and his friends from all danger of prison and rise and descend. Also a machine can easily be made by which one man can draw a thousand to himself by violence against their wills, and attract other things in like manner. Also machines can be made for walking in the sea and rivers, even to the bottom without danger. For Alexander the Great employed such, that he might see the secrets of the deep, as Ethicus the astronomer tells. These machines were made in antiquity and they have certainly been made in our times, except possibly a flying machine which I have not seen nor do I know any one who has, but I know an expert who has thought out the way to make one. And such things can be made almost without limit, for instance, bridges across rivers without piers or other supports, and mechanisms, and unheard of engines.

Since Bacon's authority concerning Alexander is unreliable and his conjecture concerning ancient scythe-bearing chariots unwarranted, we may also doubt if steamboats and automobiles had "certainly been made" in his day; but there seems little doubt that men were trying to accomplish such things.

The modern science of geology was a sealed book both to the middle ages and to antiquity. But in geography the middle ages seem to have preserved the knowledge of the ancients and to have added considerably thereto. The north of Europe and its adjacent seas now became better known. In the thirteenth century medieval missionaries and travelers penetrated to the far East, and the accounts of the Venetian trader, Marco Polo, and of the Franciscan friar, William of Rubruk, gave information concerning China and Japan,—lands practically unknown to the men of classical times. The mariner's compass must have been known in western Europe by the twelfth century; it is first mentioned by Alexander Neckam, the same man who thought that Adam's fall caused the spots on the moon. It very possibly was a western invention, since it can hardly be proved that it was known before this in the Orient, where some think that it was first introduced by the Portuguese. After Neckam the compass is frequently referred to by western writers and was evidently in common use. The old story that sailors were long afraid to use the new instrument lest they be accused of magic seems to be an arrant fabrication with no foundation in the writings of the time, which speak of the invention in a tone of perfect freedom and unconcern. In the fourteenth century came the development of deep sea sailing and Atlantic navigation; and the Portuguese by 1350 had discovered the Canary, Madeira and Azores Islands. The Italian sailors became so expert in charting coasts that Professor Beazley affirms that a certain fourteenth-century map of the Mediterranean is superior to any other until as late as the eighteenth century. Thus in the middle ages the foundations were laid for the circumnavigation of Africa and discovery of America in the last decade of the fifteenth century. Already in Dante's time every well-educated person knew that the world was round and that the people on the other side could not possibly fall off; and any one who read Pliny and Seneca, as every medieval student of nature did, could read, as Roger Bacon did, that the space dividing the west of Spain from the east of India was not great. Other authorities, however, made the distance much greater.

Alchemy, the art which strove to convert metals of less value into gold, is usually associated especially with the middle ages, and regarded as a proof of their superstition compared to the scientific perfection of modern chemistry. We must make several amendments to this view. First, alchemy is in no sense peculiarly medieval but existed in the ancient Greek-speaking world and perhaps came down from ancient Egypt.

Berthelot found 160 tracts by Greek alchemists. Also, various distinguished scientists continued to believe in the transmutation of metals as late as the seventeenth century. Second, thirteenth century alchemy was less superstitious and more scientific than in previous periods, whether among the Greeks or more recently among the Arabs. This fact has been rather obscured because the editors and publishers of books on alchemy in the sixteenth century preferred to print such treatises as made great pretensions and were full of mystic language. Thus the productions of charlatans got into print and the more sober works of rational investigators remained for the most part neglected in manuscripts. These, however, have now been studied by Berthelot with the following results.

Whereas Greek tracts on alchemy are all in an archaic enigmatic style, "combining in one undecipherable medley terms of obscure meaning, magical formulas, astrological notions, citations from mystic authors, and cryptic allusions to a philosophy long since buried too deep for present resurrection"; on the contrary, the thirteenth century treatises are full of positive details and rational argument. Moreover, the medieval alchemists are careful to refute those who deny the possibility of transmuting metals, while it does not seem to have entered the heads of the Greek alchemists that any one should doubt the truth of their art. Third, this progress is not due to the Arabs. Berthelot discovered only one treatise in Arabic which contained precise and minute details about chemical substances and operations. As a rule the Arabian alchemists wrote "theoretical works full of allegories and declamations." For a long time several works important in the history of chemistry as well as of alchemy were regarded as Latin translations from the Arab Geber, who was consequently regarded as a pioneer in the history of science. Berthelot discovered the Arabic manuscripts which turned out to be of little value and largely copied from Greek sources. On the other hand, the Latin works which had gone under Geber's name were produced in the thirteenth and fourteenth centuries by men who seem, like Adelard of Bath, to have preferred to attribute their own ideas to the Arabs.

Let us examine for a moment with Berthelot the chief of these treatises. It is "a systematic work, very well arranged." "Its modest method of exposition" differs greatly from "the excessive and vague promises of the real Geber." It refutes scepticism as to alchemy in a long scholastic discussion typical of the thirteenth century. But this is no mere scholastic treatise. Parts of it possess "a truly scientific character" and show "the state of chemical knowledge and theory with a precision of thought and expression unknown to previous authors." The writer "defines carefully silver, lead and the other metals, and traces the characteristic features of their chemical history as far as it was then known. If you leave out a few incorrect details connected with trans-

mutation, all these chapters show the stamp of solid science." Elsewhere the writer describes chemical operations, and "each description is full of special details and illustrated in the manuscript by exact figures."

Roger Bacon, too, shows us that alchemy was not intent merely upon transmutation, when he defines it as the science "concerning the generation of things from the elements, and concerning all inanimate things, such as the elements and humors single and compound, ordinary stones, gems, marbles, gold and other metals, sulphurs, salts, dyes and colors, oils, bitumen and countless other things." The invention of gunpowder has sometimes been attributed to Bacon, probably incorrectly; but he mentions some explosive as already in common use in children's toy caps and torpedoes.

We have already seen that there was a good deal of scepticism about the transmutation of metals in the thirteenth century. The consensus of learned opinion was that most alchemists produced a mere appearance of gold which would not stand severe tests. However, it was believed that by reducing the metals to their constituent elements or to first matter one might then combine them anew into gold. The difficulty, of course, was in not realizing that the metals themselves were elements.

Astrology was another medieval study which, like alchemy, was partly scientific and partly superstitious. No clear distinction in meaning was observed between the words astronomy and astrology. Either one was used to include both knowledge of the movements of the heavenly bodies and prediction of the future from them. Indeed, it was largely due to this sensational and superstitious side of the subject that sober astronomical observations made so much progress in both antiquity and the middle ages. Astronomy in those days was the most advanced of any natural science, although the Copernican theory and the telescope were as yet in the future. Astronomy was classed as the chief of the liberal arts; numerous treatises concerning the heavens were composed; Ptolemy's out-of-date astronomical tables were replaced by those of King Alfonso the Wise of Spain; Roger Bacon pointed out the need of reforming the calendar which Pope Gregory accomplished centuries later; in 1344 an archbishop of Canterbury was the first to expound the correct theory of polygonal stars.

Moreover, astrology, like alchemy, became more scientific in the thirteenth century than before, and it supplied what may almost be called the fundamental scientific hypothesis of that period. The middle ages no longer regarded the planets as gods; and they did not so much emphasize the notion that the fate of this or that man can be predicted from the constellations, as they did insist that the whole world of nature on our globe was controlled by the orderly, unceasing and unchanging revolutions of the heavenly bodies. All generation and corruption in

organic life was supposed to be so controlled, and even inorganic matter was thought to receive impressions from the stars. Even the members of the human body were parceled out under the control of the different planets and signs of the zodiac. How far one thought human fate under the stars simply depended on how far one attributed human action to appetite and environment, rather than to reason, will and divine interference. In any case, astronomy and astrology must be reckoned with in botany, zoology, mineralogy and medicine; and became the supreme science, the one underlying the rest.

Furthermore, astrology was no easy art, but had a very complicated technique as well as an enormous scope. The pursuit of this intricate superstition must, like the disputations and carefully analyzed arguments of the scholastics, have exercised a beneficial effect upon the muscles of the human mind. It has always been a matter of some wonder to me that, even after astrology was proved to be false, its former devotees did not continue to urge the study of this outworn subject on the ground that it would provide good mental discipline.

Medieval medicine was connected with natural science, and sometimes with astrology; but there is not time to speak of it now except to say that there were several schools or university faculties of medicine, that numerous medical treatises have come down to us, and that, while in the main medicine was still controlled by the theories and authority of Galen, there seems to have been some progress. Surgery received a new impulse in Italy in the thirteenth century, though the epoch-making discoveries of Vesalius and Harvey were still far in the future.

We have seen that Aristotle was not the sole authority of medieval science; I wish now to emphasize that it did not rely solely upon authorities, no matter how numerous. We have already heard Adelard prefer reason to mere authority, but besides reason medieval students of nature recognized observation and experience as criteria of truth. Albertus Magnus, for instance, in the later books of his work on animals, often says, "I have tested this," or "My associates and I have experienced this," or "I have proved this is not so," or "But I have not experienced that." When discussing whales, he "passes over the writings of antiquity on this topic because they do not agree with experience," and gives his own personal observations instead. Often, indeed, he questions the reliability of former writers, drawing a sharp line between those who state what they themselves have seen or experienced and those who appear to repeat rumor or folk-lore. He will not accept everything that Pliny the Elder says in his "Natural History," and he is particularly chary of accepting the assertions of Solinus and Jorach, assuring his readers that

> those philosophers tell many lies and I think that this is one of their lies.

In his treatise on plants, too, which has been called the chief work

in botany between Theophrastus and Gesner, Albert limits himself to "those plants better known among us." Of some of these he has personal knowledge, for others he cites those writers

who are not too ready to state anything unless it is proved by experience. For in such matters experience alone gives sure information.

Again in his "Physics" Albert states that

a conclusion contrary to the senses is incredible; and a principle which does not agree with experimental knowledge acquired by the senses is no principle but quite the opposite.

Indeed, medieval men not merely trusted in observation and experience; they experimented. The inventions which we have mentioned involved experimentation. The efforts of the alchemists involved experimentation. We have heard Peter of Spain contrast "ancient philosophers" with "modern experimenters." Roger Bacon has been given undue credit for his discussion of "experimental science," and has been lauded as the first prophet of modern science in the wilderness of scholasticism. But his views seem to have really been the common property of his age, as I have shown more fully in an article upon "Roger Bacon and Experimental Method in the Middle Ages," which appeared in *The Philosophical Review* (May, 1914).

So far we have considered the serious side of medieval science and the progress which was then being made, slight indeed compared with the rapid strides of science in our own time, but well worth the notice of any one interested in science's first steps. But it would be unfair to stop there; if we disclose medieval science's merits, we must also draw forth its frailties and lay bare the superstition, the absurdities, the credulity which characterized the study of nature then. Fortunately this side of medieval science is as amusing as the other was serious.

The credulity of medieval men is something astounding. Roger Bacon and Albertus Magnus are both sceptical at times. Then again they simply amaze one by their incomprehensible gullibility. For instance, Bacon classifies the prophetic writings of Merlin among "reliable authorities"; he tells of a woman of Norwich who lived without food for twenty years, "as the bishop proved by a trustworthy examination"; he says that "papal letters attest" that a German captured by the Saracens received a medicine which prolonged his life to 500 years. He has "learned without deceit or doubt from men of proved faith" that "good flying dragons" still exist in Christian Europe, and that eating their flesh will prolong life and develop the mind to a high degree. Moreover, some of these assertions occur in the very midst of his discussion of experimental science. Albert is somewhat less credulous on the theme of dragons and suggests that meteors or flaming vapors may have been mistaken for flying dragons breathing fire. But Albert falls a victim to a sea-serpent yarn, having "heard from trustworthy

persons" that a serpent with the virgin countenance of a beardless man was recently killed in an island of Germany. Another "trustworthy person" told him that he saw in an eagle's nest 500 ducks, over 100 geese, about 40 hares, and many large fish, which were all required to satisfy the hunger of the young eaglets.

Besides miscellaneous instances of credulity, and the errors of alchemy and astrology already mentioned, we find medieval books on nature full of marvelous and fantastic properties attributed to plants, stones, birds and beasts. Especially wonderful powers are attributed to gems. A French Bishop Marbod in his book on stones tells us that the sapphire nourishes the body and preserves the limbs intact. One who carries it can not be injured by fraud or envy, and is impervious to fear. It sets prisoners free; and is even represented as placating God and rendering him favorable to prayers. It makes peace between foes. By means of it the future can be predicted. It cools one off and checks perspiration. Applied in a pulverized state with milk, it heals ulcers, cleans the eyes, cures headache and ills of the tongue.

But plants, too, as well as gems, have remarkable powers. The German abbess Hildegard, in her work on "The Subtleties of Diverse Creatures," mentions certain plants which fish eat, and which, if a man could procure and eat, would enable him to go without food for four or five months. Adam used to eat them now and then, after he had been cast out of Eden, but not when he could get other food, since they make one's flesh tough. As for the strange virtues possessed by birds, Hildegard tells us that mistiness is marvelously removed from the eyes by catching a nightingale before daybreak, adding a single drop of dew found on clean grass to the bird's gall; and anointing the eyebrows and lashes frequently with the mixture.

Hildegard's chapters on quadrupeds are delightfully quaint. The camel is peculiar in that its different humps possess different virtues. The hump next its neck has the virtues of the lion, the second of the leopard, the third of the horse. Unicorns can never be caught except by means of girls, for they flee from men, but stop to gase diligently at girls, because they marvel that they have human forms, yet no beards. "And," adds Hildegard,

> if there are two or three girls together, the unicorn marvels so much the more and is the more easily captured while its eyes are fixed upon them.

When a weasel is sick, another weasel digs up a certain herb and breathes on it for the space of an hour and then brings it to the sick weasel who is cured thereby. This herb is unknown to other animals and to men, and it would do them no good if they did know of it, since its own virtue is not efficacious, nor would their breathing upon it make it so. But the heart of a weasel, dried and placed with wax in the ear, benefits deafness or headache. A fine cure for epilepsy is to

put a mouse in a dish of water and then give this water to the patient to drink, not to mention washing his forehead and feet in it. As with drinking Postum instead of coffee, "There is a reason." It is this,

> Inasmuch as the mouse runs away from everything, therefore it drives away the falling disease.

Marbod and Hildegard were twelfth-century writers, and somewhat naïve and undiscriminating in their acceptance of marvels. The thirteenth-century encyclopedias and works on medicine do not contain so much chaff in proportion to their wheat; but they still contain a great deal. Even Roger Bacon, who declared false and disproved by experiment several such notions as that only goat's blood can break adamant and that hot water freezes faster than cold,—even Bacon still speaks of the "almost miraculous" powers of "herbs and stones and metals." However, the writers come to recognize that there is something peculiar and requiring explanation in these strange properties ascribed to the things of nature. In the thirteenth century they are distinguished as occult virtues and are regarded as marvelous. It is admitted that reason can not account for them, but their existence is declared to be attested by experience.

Thus Albertus Magnus admits that it is difficult to explain the strange virtues of gems, and says that many students of nature seem to doubt whether stones possess any such attributes as to cure ulcers, counteract magic potions, conciliate human hearts, and win battles. But he insists that these occult virtues are well-established facts, and gives two examples attested by his own experience, namely, the magnet's power to attract iron and a sapphire which he saw cure ulcers. Some plants, too, Albert declares, have "divine effects which students of magic especially investigate."

On the other hand, Vincent of Beauvais, while he still agrees with Marbod that the virtues of gems are so marvellous that they can be accounted for only as the result of direct divine influence, thinks that plants possess only natural powers, which are chiefly medicinal. Nor does either Albert or Vincent usually recommend fantastic or irrelevant methods of using herbs medicinally. Many, however, of the medicinal virtues which they ascribe to plants are probably false, and they also show a tendency to make each plant a panacea for a long list of very miscellaneous and unrelated diseases. This may be illustrated by a passage taken quite at random and which happens to be about the nasturtium:

> It is acid and hot and dry. It is a gentle purgative and laxative, and dries up the gases of an empty stomach. Used as a potion or liniment, it keeps one's hair from falling out. It is beneficial for abscesses and carbuncles, if taken with salt and water. . . . It is good for softening of the muscles, puri-

fies the lungs, helps asthma, heats stomach and liver, cures enlargement of the spleen,

and so forth.

To animals amusing habits and human characteristics as well as occult virtues were sometimes ascribed by the encyclopedists. Thus in describing the lion Albert devotes half his space to the noble and genial personality of the king of beasts, and to discrediting scientific scandal about the wiles of the lioness to conceal her *amours* with the leopard. Then we come to marvelous virtues. A man anointed with lion's fat puts every animal to flight. A diet of lion's flesh is good for paralytics. Garments wrapped in a lion's skin are secure from moths. If the skin of a wolf is left near the skin of a lion, the hair soon falls out from the wolf-skin. The tooth of a lion, suspended around a boy's neck before he loses his first teeth, protects him from toothache when the second teeth appear. Lion's fat should be used in unguents to remove blotches from the skin. Cancer may be cured by an application of lion's blood. Drinking some of a lion's gall cures jaundice. Eating its brain is a cure for madness.

If the encyclopedists attribute marvelous medicinal virtues to individual things, the medical treatises proper prefer elaborate concoctions. Sometimes the ingredients of these formidable mixtures might excite no surprise if administered separately, but the multiplicity and diversity of their combination seems strange indeed. Sometimes the recipes are utterly fantastic. Bernard Gordon assures us that for cure of eye-troubles "God even to these times has never vouchsafed to reveal a better remedy" than a combination in varying amounts of mountain willow, majoram, eufragia, celidonia, fennel, ginger, spikenard, pepper, gariofil, thucia, Persian gum, ass's milk, aloes wood, the gall of an eagle, a hawk and a mountain goat, balsam and honey. Of these ingredients

those that need pulverizing are to be pulverized; those that ought to be shaken well are to be well shaken; those that should be reduced to liquid form are to be liquefied. Then, if it is summer time, they should for forty days be mixed in the hot sun, and stirred daily. And if it be winter, let the mixture be prepared with cinders, where the heat is about that of a sitting hen; and let it be stirred and kept in a glass vessel, and dropped into the eyes; and it is of so great virtue that it enables decrepitude to read small letters without eye-glasses.

Thus in the midst of a superstitious recipe we get evidence of a scientific invention.

Even the experiments of medieval men were affected by this belief in occult virtues, and sometimes resembled the tricks of magic more than the scientific procedure of a modern laboratory. Roger Bacon advocates experimental science at considerable length, but he calls the following an experiment.

A sage at Paris recently cut a snake into small sections except that the skin of its belly on which it crawled was left intact; and that snake crawled as best it could to a certain herb, by touching which it was instantly made whole. Thus the performer of the experiment discovered an herb of wonderful virtue.

But Albertus Magnus has an experiment to match this. He says:

'An emerald was recently seen among us, small indeed in size but marvelously beautiful. When its power was to be tested, some one suggested that if a circle was made about the toad with the emerald and then the stone was displayed to the toad, one of two things would happen. Either the stone would be broken by the gaze of the toad, if the stone was of weak virtue; or the toad would burst, if the gem was in its full natural vigor. Things were immediately arranged as suggested, and, after a moderate interval of time, during which the toad kept its eye unswervingly upon the gem, the latter began to crack like a nut and a portion of it flew from the ring. Then the toad, which hitherto had stood immovable, began to move away, as if it had just been freed from the power of the stone.

While medieval men still accept in large measure these far-fetched virtues, they have a semi-scientific theory to account for them. It is not a case of unreasoning superstition. They agree that no satisfactory physical explanation of such virtues can be given, that the varying composition of objects from the four elements is not enough to account for such powers. Vincent thinks them due to divine influence, Hildegard sometimes connects them with demons; but other writers, as Roger Bacon, Peter of Abano, and Thomas Aquinas, attribute them to the influences impressed on matter by the stars. Here again we see how important a part astrology played in medieval science.

We, however, can find an explanation which will explain both the belief in occult virtues and the belief in astrology. They are survivals from magic. The conception of occult virtues in particular objects is magical. Much sympathetic magic, too, may be found stranded on the shores of medieval science, as is seen in the reasoning why the mouse cures epilepsy, and in the eating of lion's flesh in order to grow strong. Furthermore, incantations, amulets, characters, astrological images, are occasionally found in medieval science and medicine. Sometimes their experiments seem like feats of magic.

The reason for this is that science and magic were for a long time closely connected. As anthropologists have shown, magic plays a great part in the life and thought of primitive peoples, and it is only gradually that the science and religion of civilized peoples free themselves from the old habits and instincts. True, it is one of the glories of modern science that it has freed men from superstition and mental anarchy. But science did not come down from above nor invade from without. It grew up in the very midst of superstition and mental anarchy, just as the states of modern Europe had their beginnings in feudal society. As the kings in the middle ages had to govern under feudal limitations and even by feudal means, so science for a long time

not merely was opposed by the unscientific attitude, but was itself tinged by fantastic theories and false data. Yet the scientific attitude, like the spirit of nationality, was at work in the seeming chaos; gradually it shook itself free from error, and, by the increasing application of truly scientific methods, won a similar triumph to that which the sovereign political power gained by its gradual development of governmental institutions.

This was the process going on in the twelfth and thirteenth centuries. When men still believed in demons and witches and divination from dreams, it is not surprising that they believed also in natural magic. Only a small part of nature's secrets were revealed to them; of the rest they felt that almost anything might turn out to be true. It was a time when "one vast realm of wonder spreads around." They had to struggle against a huge burden of error and superstition which Greece and Rome and the Arabs handed down to them; yet they must try to assimilate what was of value in Aristotle, Galen, Pliny, Ptolemy, and the rest. Crude naïve beginners they were in many respects. Yet they show an interest in nature and its problems; they are drawing the line between science and religion; they make some progress in mathematics, geography, physics and chemistry; they not only talk about experimental method, they actually make some inventions and discoveries of use in the future advance of science. Moreover, they themselves feel that they are making progress. They do not hesitate to disagree with their ancient authorities, when they know something better. Roger Bacon affirms that many scientific facts and truths are known in his time of which Plato and Aristotle, Hippocrates and Galen, were ignorant. The ancients, says Peter of Spain in effect, were philosophers, but we are experimenters. Magic still lingers but the march of modern science has begun.

A HISTORY OF FIJI

By Dr. ALFRED GOLDSBOROUGH MAYER

Part III

Of all established customs in Fiji the most odious was cannibalism, yet it was always tabu for women and the lower classes, and the custom was extensively practised only by the chiefs and warriors. It is possible that in Fiji it was primitively a religious rite and did not originate in time of famine, or through motives of mere revenge. Instead of an animal, they sacrificed the best they had to the gods, and as the flesh of the animal was eaten by the chiefs, so was the flesh of man. Indeed, an old myth asserts that once there was no cannibalism in Fiji, and even when it was most prevalent there was always a party opposed to it, maintaining that it caused various skin diseases. At the town of Nakelo on the Rewa river, it was tabu to eat human flesh.

We incline, however, to the belief that the Fijians were cannibals simply because they enjoyed the taste of human flesh, for I have met with no dissent to the opinion that of all meat it is the most palatable, and it is evident that the custom could not have survived a decade had mere religion prompted its continuance. The fact appears to be that, in common with other privileges, the chiefs and priests had succeeded in monopolizing its pleasures through the agency of the tabu, for among savages the priesthood is quick to defer to the desires of those in power. In prehistoric times the natives had but little animal food, apart from the fish of the reefs and the snakes of the mountains, for pigs, ducks and chickens were introduced only recently. When man attempts to live upon a vegetable diet, even though it be varied by fish, an insatiate craving for animal food comes over him, he "Kalau's," as the natives say, and it is an interesting fact that cannibalism is almost unknown among peoples whose meat-supply has always been abundant and varied. Once it be acquired, this longing for human flesh remains a temptation haunting its possessor. Well does one remember the vim of a wild Marquesan dance. It was near midnight and the flickering glare of the bonfire cut into the blackness of the surrounding forest. An old chief, standing by the embers, led the chant, while his tribesmen, with hands joined, danced furiously around him. Translated into English, the burden of their song was "I have eaten your father, your mother, your brother, now I intend to eat you! whoo!! hack!!!"—in a bestial shriek that rang back in echoes from the cliffs. Then, one by one, at unexpected times and from unforeseen recesses, the maidens of the tribe emerged from the dark aisles among the trees; their graceful bodies glistening where the fire-light glinted upon the cocoanut oil that

covered their shapely limbs. Gay flowers stood out among the riot of their flowing locks, and like elfin things they flitted with tremulous arms outstretched until they stood fully revealed in the red glare, only to flutter silently backward and vanish. In days gone by that darkness concealed from view a gruesome meal.

Basil Thomson points out the fact that in Fiji the practise increased greatly just before the coming of white men, as had that of human sacrifice among the Aztecs a few years before the arrival of Cortez. With the sudden increase in the power of the great chiefs, it began to lose its religious significance and an acknowledged appetite for cannibal meat was boastfully proclaimed. Thus Tanoa, Ra Undreundre, Tui Kilakila, and others were cannibals because they enjoyed the taste of man, but not *all* Fijians liked human flesh, even as terrapin is not enjoyed by all white men.

The most hideous features of cannibalism were the fiendish tortures, Vaka-totogana, connected with it wherein the victims were gradually dismembered and their noses, tongues, arms, or legs cooked and eaten before their eyes, pieces of their own flesh being offered to them in derision. Even if the missionaries had accomplished nothing else, their success in abolishing cannibalism would have sanctified their labors. Let nothing blind us to an appreciation of the undaunted courage and unexcelled devotion to their faith displayed by these unselfish men and women, who, actuated by high and simple motives, left homes and friends, and labored cheerfully through long years over the seemingly hopeless task of bringing the light of a happier day to the barbarians of Fiji.

People who had died a natural death were rarely or never eaten, and only those killed in battle, captured, or wrecked "with salt water in their eyes," were offered to the gods and roasted. The dead, if killed in battle and buried, they would disinter even after the tenth day when the body could not be lifted entire from the grave and was therefore torn apart and made into puddings. Every one agrees that decomposition did not deter their appetite for human flesh, any more than it impairs our own taste for game, yet all other meat was discarded by the Fijians as by us upon the least indication of dissolution.

Among old Fijian chiefs whom I knew between 1897–1899, none expressed the slightest abhorrence of cannibalism, and some were frank enough to state that were European influences removed they would at once renew the practise. To the Fijian no revenge is assuaged until you have eaten your enemy, but the deepest contempt for a fallen foe was indicated by roasting and then refusing to devour the body.

One of the best descriptions of a cannibal feast is that given by Jackson in Erskine's voyage published in 1853; and the Rev. Thomas Williams[1] in his work upon "Fiji and the Fijians" describes the rites in detail, having often observed them.

The canoes when approaching the shore would indicate that human prey was on board by striking the water at intervals with a pole. Seeing the splashes, the natives gathered in a howling mob along the shore, the women breaking into a wild, lascivious dance. The victims were seized by the arms and dragged to the temple, their captors chanting the cannibal song:

Yari au malua. Yari au malua.
Drag me gently. Drag me gently.
  Oi au na saro ni nomu vanua.
  For I am the champion of thy land.
Yi mudokia! Yi mudokia! Yi mudokia!
Give thanks! Give thanks! Give thanks!
  Ki Dama le!
Yi! u-woa-ai-a!

Sharp-edged strips of bamboo served as knives for the butcher, and after being roasted or steamed, the flesh was eaten by means of a wooden fork, each high chief having one of these which it was tabu for any one but himself to touch.

Cannibalism was dreaded by the lower classes for they were forbidden to participate in the feasts, and were themselves most frequently the victims of these orgies. Thus when the missionaries succeeded in developing even in a rudimentary form the force of "public opinion" the practice was suppressed far more easily than had been anticipated, for it was a rite maintained by the aristocracy and the priests and had become a terrible engine of despotism.

Another institution which appears to have been practised from time immemorial in Fiji was polygamy. The great majority of Fijians were not polygamous, however, for only the highest chiefs could afford to maintain more than one wife, and even those of most exalted rank rarely had more than ten wives. There is reason to suppose that the number of women has always been less than that of men in Fiji, owing to the greater care devoted to the rearing of warriors.

A man of the middle classes rarely married before the age of twenty-five, at which time his mother chose a wife from among the daughters of his maternal uncle (his orthogamous cousins, veidavolani). One quarter of all Fijian marriages are still of this character, and they produce healthy offspring.

Men of the lowest class frequently remained bachelors throughout life, and all unmarried females of the peasantry were disposed of by the chief of the tribe. In Mbau this match-making chief was next in rank to the vunivalu, Thakombau. It is evident that Basil Thomson is right when he says that the abandonment of polygamy could have had no serious influence upon the vitality of the race, for it affected too few.

[1] Williams was by far the most assiduous and accurate observer of Fijian customs, and it is to be regretted that his manuscript was edited and "repressed" by a Mr. Rowe of London who had never visited Fiji.

It is a common mistake to assume that social anarchy is the rule in primitive communities; for the reverse is true, and savage races are the ones *par excellence* most dominated by established forms, their system of life remaining unchanged for generation after generation. This is illustrated most clearly in an interesting paper by Lord Amherst of Hackney and Basil Thomson published by the Hakluyt Society of London in 1901, which shows that, since their discovery in 1568, the customs of the Solomon islanders have remained absolutely unaltered, until crushed under the rule of white men.

Among these fixed customs of savage tribes, some are actually better than our own. Thus in Fiji prostitution was checked as effectively as any mere system could prevent it. This was accomplished by obliging all the unmarried men to sleep each night in a special house, the Mbure-ni-sa, or men's house, while the virgins were kept at home with their parents.

Indeed, the use of the Mbure-ni-sa was even extended, under certain conditions, to the married men. There were no milk-producing animals in Fiji, and the food of the natives is still so deficient in animal proteids that it can hardly afford sufficient nourishment for healthy growth until the child is nearly four years old. Accordingly, when a child was born, husband and wife separated; she going to live for a year with her mother's relatives, and he to sleep for the following two or three years in the Mbure with the unmarried men. Thus throughout the suckling period the risk of a new conception was avoided, and the full strength of the mother was preserved to nourish her infant.

Unhappily, the Europeans saw fit to break up this system, maintaining that it interfered with family life and was destructive of mutual affection. The tabu having thus been abolished, conceptions often occur within a year following the birth of a child, and the mother's milk is rendered inefficient as a means of nourishment, while at the same time the drain upon her strength is so great that the unborn child may not properly develop. Thus the new system has increased the birth-rate, but at the same time produces weak, sickly infants whose death-rate is far greater than in former times. This indeed is one of the most potent causes of the decrease of the Fijian population, especially as the married women now attempt to escape the strain of these exhausting pregnancies by resorting to abortion, a practise which has increased in recent years to the serious impairment of the vitality of the race.

Moreover, the abolition of the Mbure-ni-sa has brought about a too sudden and promiscuous commingling of the young men and women, and the commission appointed by the British government to inquire into the causes which are producing the decline of the Fijian population has decided that sexual depravity has increased since the abandon-

ment of heathenism, for licentiousness formerly kept down by the chief's club is now merely forbidden.

Seeman states that the natives were shocked when he told them that English women frequently bore children at intervals of a year apart, and upon reflection they decided this accounted for there being so many "shrimps" (small men) among Europeans.

In common with some other primitive races, the Fijians looked frankly upon those problems of sexual relations which we attempt to ignore or to cloak under a mantle of secrecy, too often pernicious to the welfare of our race. The average European is too apt to be horrified when he hears a spade called by its simplest name, and to his mind morality implies an unnatural hypocrisy respecting the physiological facts of life. He forgets that acts and words are in themselves innocent unless their *intention* be otherwise, and in many matters of this sort the missionary has unfortunately made cowards and liars of his converts, and it is undoubtedly true that the influence of civilization in the Pacific has tended to increase rather than diminish all forms of clandestine sexual depravity.

I have heard competent and unprejudiced observers state that the Fijians were fully as affectionate in heathen times as at present. Family affection fortunately springs from nature itself and is not a product of our system of life, however cultured or barbarous. One sees the naked women of Australia, whose bodies are covered with self-inflicted scars, gaze rapturously upon their children and exhibit maternal love as truly as could any European mother, and even Wilkes, who refers to the Fijians as "the most barbarous and savage race now existing upon the globe," states that he saw "engaged couples walking affectionately arm-in-arm as with us."

One of the saddest, because the most apparent change that has affected the lives of the Pacific islanders is the needless decay of their arts. War, and the ceremonies and obligations of religion once provided the major motive for the maintenance and development of varied crafts. In fact, the intent of practically every piece of decorative work was either to propitiate the gods and tribal spirits, or to frighten a real or imaginary enemy. Nor is this peculiar to savage tribes, for all the complex ornaments which adorn the yokes of horses in Naples are "evil eye" charms which have come down almost unaltered from Roman times.

The missionary soon saw that most of his so-called converts had only added the white man's god to those of their ancestors. In order, therefore, to obliterate old beliefs, he discouraged the making of all "symbols of heathenism," and, as these were displayed in almost every implement, art fell at once under the awe-inspiring ban of his displeasure.

Yet the decline of native art was to some degree inevitable even if

the missionaries had attempted to foster and preserve it, for it perished chiefly because of its inadaptability, and the absence of a market for its wares. The cheapest calico is softer and more enduring than the best of tapa, the coarsest canvas sail is superior to that woven of pandanus leaves, the beautiful adze of polished stone fails wholly when placed in competition with even the "trade hatchet."

Yet in each group there was at least some native art which, had it been cared for by the whites, might have been preserved so that in a more or less modified form it might have furnished a permanent and progressively important means of livelihood to the natives, and thus have become a means of maintaining their racial entity and self-respect.

Art was the highest expression of their intellectual life, an absorbing field for their ambition, a means of gratifying their instinct for the beautiful, and a record of their history and their conception of the universe. It meant far more to them than it does to us with our widely varied interests, and to this the European was blind when he permitted its destruction.

All over the south seas in proportion as white men have become dominant native arts have withered. Once the canoe was built of separate pieces skilfully calked and lashed together, and its outrigger was a marvel of flexibility and strength. Yet everywhere it degenerates into a crudely hollowed log, crossed by two rough sticks to which the outrigger is rigidly tied. The house, once shapely in form and carefully thatched, degenerates into a mere shack, and every carved bowl, paddle and implement becomes rude, ugly and misshapen. All care in manufacture degenerates, and in proportion does the light of their intellectual life fade out. A hopeless apathy, a listless lack of interest in all around them overcomes their dulled minds and their lives, like those of prisoners, are no longer worth the while of living, for hope can not flower within the stifle of the cold gray walls of bigotry's bastile.

Pleasures and sports suffer as do the arts. The surf-board riders of Hawaii are now rarely seen, dances and songs are being constantly suppressed, and many happy things that once filled their minds with joy, and were beautiful in their eyes, have vanished never to be theirs again. But one resource is left to their idle minds, and clandestine immorality saps their strength. As the Government Commission in Fiji reports

> premature civilization, mental apathy and lack of ambition under the new conditions are among the most important causes of the decline of the population.

This carefully selected commission was appointed by the British government in Fiji to inquire into the causes of the decrease in the native population, and after long investigation the conclusions of the commissioners were published by the Colony in 1896.[2] It is probable

[2] Report of the Commission appointed to inquire into the causes of the de-

that in 1859 there were about 200,000 natives; in 1868, 170,000; in 1871, 140,000; in 1881 there were 114,700 and in 1891, 105,800 while in

ILLUSTRATING THE DECLINE IN THE NATIVE POPULATION OF THE FIJI ISLANDS FROM 1859 to 1911.

1901 the population had still further declined to 94,400, and the males outnumbered the females in the proportion of 8 to 7. In 1911 there were but 87,096 natives, and if the decline continues at its present rate the last Fijian must die before another century has passed.[3]

The commission decides that children have ceased to be useful, and whereas in old days they strengthened the tribe in war, they now suffer neglect. The birth rate is higher than that of England yet only 11/20 of the children survive to be one year old.[4] Another cause is said to be the general want of vitality due to the effects of past epidemics, such as the "wasting sickness" in 1797, the dysentery of 1803 and the measles of 1875. One is, however, inclined to believe that no permanent evil effects could be produced as a result of these physiological disasters. No matter how severe the epidemic, those who are physically the best are the most apt to survive and become the progenitors of successive generations, and thus the race might even be improved through natural selection. There is no evidence tending to prove that the black death

cline of the native population. Published by the Colony of Fiji, Suva, 1896, pp. v + 130.

[3] Should the natives continue to decline at the rate which has pertained since 1881 they must become extinct in the year 2004.

[4] Within recent years the medical department under the able leadership of Doctor G. W. A. Lynch has been enabled to take measures which appear to have reduced this infant mortality so that nearly 78 per cent. of the children survive the first year.

of the fourteenth century or the plague in London in the time of Charles II. resulted in any permanent physical deterioration of the races they affected. The Fijians may be a vanishing people, but in physical appearance they remain superior as of old, and their superb stature and mental attainments appear not to have declined even though the race as a whole be dying.

There is, however, one cardinal evil in the Fijian situation and that is the severe strain of child-raising which falls upon the women in a country wherein the proper food for the maintenance of lactation has not yet been produced in sufficient quantity. The children, being thus in a peculiar sense dependent upon their mothers, will be profoundly affected by any conditions which produce injury to the women of the tribe.

Yaws, dysentery and whooping cough are now primary causes of the decline of population. Among minor causes the committee mentions the abolition of polygamy; for under monogamy the mother must not only tend her child, but gather the food and cultivate the soil, whereas in polygamous days these latter duties were taken over by the other wives during the early period of the infant's life.

The report makes it clear that the decline is due chiefly to the high death rate of children, and also that we must proceed very slowly and sympathetically, using as little force as possible, in the introduction of civilization. The old socialism must gradually be replaced by a certain measure of individualism, and the warrior's ambitions must give place to those of the craftsman. Hygiene as a subject of primary importance must be taught not only in the schools, but chiefly by example, upon the plan of the college settlement, by teachers living in so far as possible as the natives themselves now live, thus *slowly* changing the habits of life of those around them, and indeed these teachers should themselves *be natives* of the most enlightened type, and maintained in government employ.

A most interesting sociological experiment has been conducted by the British in their government of the Fijians. It is one of the very few instances wherein altruism is the key-note in the rule of the strong over the weak, and its maintenance through all these years in the face of much discouragement and expense is an honor to Great Britain, in the pride of which all the world may share—it is a rare triumph of idealism over selfishness.

As Mr. Allardyce, then colonial secretary, said to me:

> We came here not as conquerors but through invitation, and the best we have to give is none too good for these people who have entrusted their destiny to our care.

Indeed, if the South Sea Islanders are now to be saved *new* interests and *new* arts must be developed by them, and new ambitions other than the withered remnants of the old must be created. Industrial schools

are sadly needed in the Pacific, and the dawn of the first real progress will appear when men like Booker Washington arise among the natives of Fiji. The establishment of non-sectarian manual training schools such as his, in so far as possible under *native* teachers and supported by *native* efforts, might soon revolutionize their whole system of life, and change them from well-behaved captives into purposeful men and women.

The missionaries now conduct nearly all the schools in Fiji, and it is much to their credit that illiteracy is almost as rare as in Germany, all the present generation being able to read and write their own language. These schools are fundamentally good, but the natives should be taught not only how to pray, but also how to labor and to live. The missionaries would doubtless welcome an opportunity to extend the scope of native education, but the expense of establishing trade schools is too great for their resources and the project demands government aid. That the return to the state would ultimately far more than repay the outlay can not be doubted, for even the non-altruistic Dutch well know the profit accruing to Java and hence to themselves through the establishment of agricultural schools for natives.

Every indication of an initiative among the Fijians in the direction of craft-development should be wisely encouraged instead of being, as at present, smothered under the cloak of a paternalism that obliterates error only by crushing endeavor.

It may be confidently hoped that the British government which has labored so persistently and at such constant expense to develop Fiji "for the Fijians" and not for the surfeit of those who would selfishly exploit the natives, will take this final step and render it possible for the natives to raise *themselves* to a position of self-dependence. This was, indeed, the confessed intention of certain high officials of the colony whom I enjoyed the pleasure of meeting when in Fiji. So consistent have the English been in their effort actually to civilize and elevate the Fijians that their policy has been pursued for years despite financial loss and the frequent protests of the whites, as is evidenced by the steady decline of the white population from 2,750 in 1871 to 2,036 in 1891, since which time it has slowly risen, becoming 3,707 in 1911. The public debt in 1910 was £104,115 and the native taxes amounted only to about £16,000, the principal source of revenue being derived from customs receipts which were £129,552, the latter being, of course, an indirect tax upon the colony itself.

Since 1874, settlers have been discouraged from employing Fijians upon their plantations, for the native population was rapidly being enslaved by the whites. In order to supply the necessary labor, Hindoo coolies from Calcutta were imported, but it seems unfortunate that these usually remained in Fiji after the expiration of their terms of service and there are now 40,300 in the group. They are a clannish,

industrious, bigoted race whom the Fijians despise and with whom they do not mingle. Indeed, there are far more half-breds between the whites and Fijians than between Fijians and Hindoos.

Although all native arts have suffered and some have wholly disappeared in Fiji, the introduction of European methods has been slower in this group than elsewhere in the Pacific. Spears and clubs and other implements of war are no longer made unless, indeed, it be to sell to tourists, and the dancing masks and wigs of former days have disappeared, along with the cannibal forks. Once the natives took great pride in their war-clubs, and a man's rank was indicated by the fashion of his club and his manner of carrying it, only chiefs being permitted to bear it over the shoulder as we would a gun. The handle was notched whenever the club had served to kill a man, and such a weapon was called a "ngandro" to distinguish it from common clubs. Indeed the more famous clubs were given individual names, a certain chief being the proud possessor of one called "the giver of rest." Elaborately carved, and built up, spears of iron-wood ten or fifteen feet long were common, and were sometimes tipped with the spine of the sting-ray, which upon breaking within the wound caused certain death. In the distant villages among the mountains of the large islands, spears and clubs were still to be seen in the houses in 1899, but from more accessible places they have long since disappeared to crowd the shelves of our museums. Everywhere the natives of the coasts have yielded, and more or less conformed to the white man's customs, but only a few miles inland, isolated by the dense forests or walled in by mountains, they were in 1900 almost as in heathen times. Yet even in these remote places the natives are not wholly separated from the world, for news is carried rapidly by word of mouth, and Wilkes speaks of a case in which a message was transmitted 20 miles through a forested country in less than six hours.

The pursuit of war was once the chief concern of the Fijians, and was often conducted in a very ceremonious fashion. An offended chief thrust sticks into the ground, and removed them only when appeased. If war was determined upon a herald was sent to the village of the enemy to announce the fact. As is universal with primitive people, the mustering of the army was the occasion for much extravagant boasting, and their faces were painted red or half red and half black. Miss Gordon Cumming gives a striking description of the wild war-dance and the boasts of the warriors who assembled at the call of Sir Arthur Gordon to take part in the war against the cannibal tribes of the Singatoka River in the mountains. "This is only a musket" cried one warrior "but *I* carry it." By contrast the men from Mbau came up in stately fashion, their spokesman saying "This is Mbau, that is enough."

The towns were often fortified with wooden stockades or stone

walls, and were sometimes surrounded by moats. There are no records of protracted sieges, for the attacking party never could carry sufficient food to enable them to remain long before the walls of the besieged. They depended almost wholly upon treachery, ambushes or sudden and unexpected assaults; and to kill a woman or a child or even a pig was considered a creditable feat, as when Thakombau's warriors returned to Mbau boasting, "We have killed seven of the enemy's pigs and two women." Before the introduction of firearms, it is probable that native warfare caused but little loss of life, for fear kept the combatants skulking at a fairly safe distance from one another.

Wilkes, who himself made war upon the natives of Malolo after they had killed Lieutenant Underwood and Midshipman Henry, describes their martial customs at great length and should be read by those interested in the matter.

The cruelties practised when a town was overcome were unspeakable, and on the island of Wakaia the chief and all within his village threw themselves over a high cliff to be dashed to death rather than surrender.

Fijian warfare, like that of cannibalism, is indeed a sordid subject. Not a single struggle waged by any tribe was for the establishment of a worthy principle. Lust for murder, the capture of women, revenge for real, or more often imaginary, insults were the actuating motives of all native wars. There is in the language no word expressing disapprobation for the killing of a human being. Indeed, no matter how brutal, treacherous or cowardly the murder of man, woman or child the murderer immediately gained the proud title of koroi, which insured to him a good position among the spirits of the world to come, and permitted him to blacken his face and chest with a peculiar war-paint. Murder was thus an open sesame to social distinction and religious well-being.

The Fijians are courageous in the sense that all men are brave when wrought up to the point of action, and when facing a situation they understand. Their first sight of a horse, however, drove even the doughtiest warriors to take refuge in the trees, and when upon a dark night Wilkes came to anchor off the coast and set off rockets, the silence of the shore broke into a long shriek of terror, village after village catching the contagion of the fright. Even to-day the white man inspires a mysterious lurking fear, and in the mountain villages and in parts rarely visited by Europeans, the women and little children shrink and run at your approach, and even the men seem somewhat "stage struck." To their minds we must be past masters of witchcraft.

Indeed, in common with all beliefs and practises which may be securely hidden from the eyes of Europeans, witchcraft still survives in Fiji, as it does among the lower classes of Europe and America. The natives are fond of the "occult" and several miracles are still per-

formed. Thus at the village of Nandawa, on Koro island, an old man stands upon a high rock and calls to the sea-turtles, shouting in Fijian, Come! Come! We are tired of waiting! upon which several turtles appear swimming toward the shore. It is highly probable that these are regularly fed and are thus always ready for the "miracle" when strangers visit the town. Koro, by the way, is the island to which the souls of all dead pigs were supposed to go to their valhalla.

At the village of Rukua on Mbenga a curious miracle play is enacted. Near the town there is a circular pit about twenty feet in diameter, the bottom of which is lined with brown-colored volcanic stones, a ring of large flat ones lying near the edge around the bottom of the depression. The pit is filled with dry sticks and a fire is maintained until the stones are red hot. Then the embers are brushed away, and out of the forest there comes a procession of young men gaily adorned with garlands of flowers and well polished with cocoanut oil. They chant as they tread slowly and deliberately over the hot stones, and then vanish into the woods, apparently uninjured; upon which pigs and vegetables are placed upon the stones and are covered with leaves and earth, and a thoroughly cooked feast is soon ready for both guests and performers. Professor Langley witnessed a similar exhibition in the Society Islands, and discovered that the radiation from the surface of the volcanic stones is very great, while the stones themselves are poor conductors of heat, thus the surface soon cools while enough heat still remains within to serve in cooking the feast. The natives can not be induced to walk over limestone, which is a good conductor and poor radiator, the surface thus remaining hot. However, the great thickness of the skin upon the sole of their unshod feet accounts in some measure for their ability to perform this "miracle." In all respects natural sole leather is superior to that provided by the "leather trust."

A pleasing art which still survives, but is doomed to extinction, is the making and decorating of tapa, or *masi,* as it is called in Fiji, where it is still used for screens in houses, and for various decorative purposes. Women alone take part in the manufacture of tapa. They carefully cultivate the paper mulberry (*Broussonetia papyrifera*), and, when about six feet high, the young trees are cut down, and the bark peeled off and soaked in water. The outer skin is then scraped off with a sharp-edged shell, and the soft fibrous inner bark is ready for beating, although it may be kept indefinitely before this process is begun. For beating, the strips of bark must be thoroughly water-soaked and soft, and two are placed one over the other upon a flattened log and beaten with a rectangular mallet, *iki,* having three of its flat sides grooved and one plane. Each pair of strips of an inch in original width may thus be beaten out into a thin sheet of felted fibers nine inches wide, although the length is reduced. Separate sheets are then welded together by beating, the overlapping edges being first glued with a paste made from arrowroot boiled in water, this welding being so cleverly done that it is

almost impossible to tell where the pieces overlie one another. The sheet is then spread upon the grass and exposed to the sun to bleach. These sheets may be very large, one we measured being 160 feet long and 12 feet wide, but Williams mentions a sheet 180 yards long!

After being bleached, they produce a pattern upon the tapa with a brown dye derived from the *Aleurites triloba,* the dull color of which is relieved at intervals by large black circular spots, thus by contrast giving a bright and effective pattern. This process of decorating is described in detail by Thomas Williams in his most interesting work upon "Fiji and the Fijians." Strips of bamboo are placed in the form of the design upon a flat surface, or the design is carved in relief in a board. Then the tapa is stretched over the template and the cloth rubbed with the dye, whereupon the color adheres to all raised places and fails to appear in the hollows, and a "printed" pattern is produced. So characteristic are the checquered patterns of the tapas of the several islands that the locality of each piece can be determined upon the most casual inspection. The black and white tapas of Taviuni are most effective, and those of Lakemba probably the most artistic made in the group. It seems strange that although these tapas have for ages been printed in designs, little or no meaning was associated with the details of the pattern. There were, however, certain appropriate patterns for weddings and other ceremonies, and the flags of the various classes of warriors were more or less distinctive. Thus at Rewa the banner of the king's or high chief's party was white with four or five vertical black stripes at one end, that of the vunivalu or general had horizontal stripes, and that of the land owners was plain white. Yet the tapa flags never became tribal emblems, on the one hand, or personal coats-of-arms, on the other, but remained merely class badges, and thus no precise symbolism was associated with the designs.

In groups other than Fiji the inner bark of the bread-fruit tree, and of the yellow hibiscus *Paritium tiliaceum* are used in making tapa. Yellow turmeric, bone charcoal, brilliant red and rich brown dyes, are displayed upon tapas of the Pacific.

The art must surely disappear, for Manchester is now printing calicos in the patterns of the native tapas and these are being sold to the islanders, who prefer them to designs of their own making. In some groups traders have brought in anilin dyes which the natives call "missionary colors," the word "missionary" being applied to almost any newly introduced thing. Thus is an ancient and primitive art being debased, and another means of employment must disappear from native life. At the time of the author's visits the beating of the *ikis* (mallets) was the most characteristic sound in a Fijian village, but in a few more years this too must go the way of many another activity which once engrossed the attention and stimulated the imagination of the natives.

Tapa in Fiji was once used for the white turbans of the chiefs and the simple waist band or *malo* worn by all men. In the case of chiefs

the ends of the waist cloth formed long streamers, those of king Tanoa being so long that they trailed upon the ground. When yaqona was served, all chiefs removed their turbans, excepting only the Roko Tui of Mbau who was regarded as being a human personification of a god.

The women never wore tapa, but were clothed in the simple *liku* or waist band of hibiscus bark or grasses which is still worn among the mountain tribes, although along the coast the Europeans have abolished both it and the *malo,* obliging all to wear a waist-cloth of calico. In some respects they were a modest people before these changes were effected, and fortunately for the natives their new rulers did not oblige them to don more clothing. In other parts of the Pacific the missionaries have forced the natives to wear European garments, far too hot for tropical climates. Such clothes are so expensive that few or none of the natives can afford to own more than one suit, and this soon becomes a filthy menace to health. Tuberculosis stalks in when European clothes appear, and all unprejudiced observers will agree that the most diseased and immoral races now in the Pacific are those who have been obliged to wear the most clothing.

Their own clothes permitted the natives to bathe freely, but the whites now demand that the natives shall don special bathing suits or at least enter the water clothed in some European garments. This practically forces them either to abstain from their health-giving sport of former times or to swim fully clothed, as they now do in Hawaii. These cold wet clothes are a cause of influenza leading to tuberculosis, and everywhere the natives are less cleanly as Christians than they were as heathens.

In former times the Fijians took great pride in the arrangement of their hair, and a wide range of individual taste was permitted in this respect, as may be seen in the illustrations given by Williams in his "Fiji and the Fijians," or the colored plate published in the narrative of the voyage of the *Challenger.* Usually they trained the hair to grow into a huge thick mop standing out on all sides fully eight inches from the head, and sometimes as much as 62 inches in circumference. In order to effect this, the hair was saturated with oil mixed with charcoal and then dyed so that blue, white, brilliant red, black or parti-colored mops were in fashion. The high chiefs had barbers whose sole duty was to care for the hair of their masters, and whose hands were tabu from feeding themselves so that others had to provide them with food and drink. Such a barber might not remove a cigarette from his mouth or hold it in his hands and was thus obliged to twist a twig around it in order to avoid the weed's coming in contact with his hands. Curiously enough, barbers might work in their gardens, but were not permitted to use their hands in eating their own vegetables. Probably no savage race devoted more care to hair and beards than did the Fijians. They are very rarely bald, and indeed this was considered to

be a great disfigurement, and the defect was concealed by a wig. To preserve these unwieldy mops of hair, the natives were obliged to sleep upon a wooden pillow which was placed under the neck and held the head four or five inches above the floor.

To the European, all customs are apt to be classed as "bad" in proportion as they *differ* from those of his own race, but it should be said that in Fiji the missionaries have been more conservative and displayed far more sympathy and sense in their reforms than elsewhere in the Pacific. Nevertheless, all forms of really active exercises or keen enjoyment have a somewhat wicked appearance to a certain type of religious mind, and unhappily the mediocre man is the one who is apt to rule in deciding the fate of such affairs. They too often fail to see that when an old custom is to be abolished *something* should be devised to take its place. Thus their vandalism of bigotry has resulted in destroying or hindering the open practise of nearly all the old arts and amusements; and almost nothing but hymns and prayers and a cheerless sabbath resembling that of Puritan days in old New England have been given to the natives in exchange for all they have been forced to surrender.

The Fijians once took great delight in their club dances, but these have now been repressed and have lost much of their former animation. In one of these festivities which we witnessed the men leaped frantically in perfect unison, branishing their clubs and throwing them from hand to hand, often shielding their eyes with one hand as if searching for a hidden or distant enemy. At regular intervals they shouted *Wa hoo!* in a fierce yell that could have been heard at a distance of a quarter of a mile, while all the village crowded in a square around the dancers, beating log drums, clapping hands and chanting something which sounded like "Somo seri rangi tu Somo seri somo," over and over again. Often the meanings of words used in their songs are unknown to the natives of modern times. Wilkes gives an excellent description of a club-dance in which the best dancers were mimicked by a clown covered from head to foot with green and dried leaves, and wearing a mask half orange and half black.

The milder mekes (songs with gestures) are wisely encouraged by the missionaries, and these are still a source of constant amusement to the natives. Fiji has not yet been suppressed into a realm of sullen silence as have too many parts of the Pacific.

There is a fascination in the elemental force of the word-pictures in these songs. We stifle in the heavy air of the dull and ominous calm. Then comes the rising roar of the onrush and our hearts go out to the frail canoes struggling so bravely in a maddened sea, and the pathos of life and death is there when the hot sun glares down once more, and the ripples glint unheedingly around the silent floating thing over which the sea-birds scream.

(To be continued.)

THE PROGRESS OF SCIENCE

THE SCIENTIFIC MONTHLY AND THE POPULAR SCIENCE MONTHLY

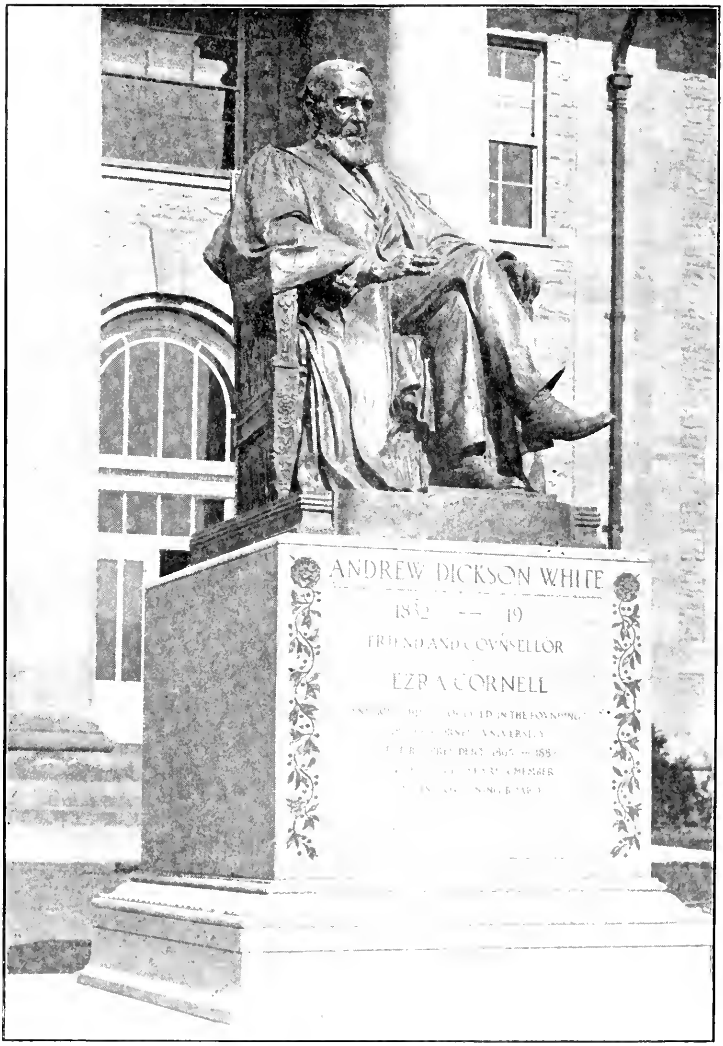
THE POPULAR SCIENCE MONTHLY, since its establishment in 1872 by J. W. Youmans and the firm of D. Appleton and Company, has endeavored to perform two functions which are somewhat distinct. On the one hand, it has aimed to popularize science, and, on the other hand, to publish articles reviewing scientific progress and advocating scientific, educational and social reforms. The objects are both important, but as science grows in complexity it becomes increasingly difficult to unite them in the same journal.

In the earlier years of THE POPULAR SCIENCE MONTHLY the doctrine of evolution excited controversy and wide public interest; it was possible to print articles by men such as Darwin, Spencer, Huxley and Tyndall, which were popular and at the same time authoritative contributions to scientific progress. Dr. Youmans had the fervent faith and missionary spirit which enabled him to conduct a journal to which the word "popular" was properly applied. At that time other magazines, such as *The Atlantic* and *Scribner's* also published articles and had departments concerned with popular science.

The last third of the nineteenth century may properly be characterized as the era of science, so rapid was the progress of science and so important the part it assumed in our civilization. This progress not only requires specialization of work, but even makes it difficult for the worker in one field to understand the work accomplished in other fields, though the barrier is perhaps due to the terminology rather than to the ideas. For the general public the difficulties are greater, and there is danger lest it may lose touch with the advances of science. But in a democracy in which science must depend on the people for support and for recruits, it is essential that a sympathetic understanding be maintained. For this purpose two journals are needed rather than one, for it is necessary to address those having different interests.

During the fifteen years since 1900, the editor of THE POPULAR SCIENCE MONTHLY aimed to conduct a journal maintaining high scientific standards and discussing authoritatively problems of scientific importance. The journal was popular, in the sense that it was not special or technical and could be understood by those having education and intelligence, but it was not popular in the sense that it appealed to all people and might number its subscribers by the hundreds of thousands. Manuscripts were received in large numbers which were clearly intended for a magazine of different type, and such a magazine is needed. A well-illustrated magazine devoted to the popularization of science should have a wide circulation and be conducted on different lines from a journal concerned with the less elementary aspects of scientific work, just as a high school and the graduate school of a university differ in their methods and in their appeal.

A group of men desiring a journal to which the name THE POPULAR SCIENCE MONTHLY will exactly apply, this publication has been transferred to them, while, beginning in October, a journal on the present lines of THE POPULAR SCIENCE MONTHLY will be conducted under the more fitting name of THE SCIENTIFIC MONTHLY. This differentiation of THE POPULAR SCI-



STATUE OF ANDREW DICKSON WHITE BY KARL BITTER.

recently unveiled on the campus of Cornell University. Dr. White, distinguished for his contributions to education, diplomacy, letters and science, contributed his chapters on the warfare of science and religion to THE POPULAR SCIENCE MONTHLY.

ENCE MONTHLY into two journals is in the natural course of evolution, each journal being able to adapt itself to its environment more advantageously than is possible for a single journal. Each can perform an important service for the diffusion and advancement of science.

SCIENTIFIC JOURNALS AND THE PUBLIC

IN a democracy, journals and a newspaper press fit to educate people of all sorts to an interest in science and to an appreciation of its measureless value for national and human welfare are matters of the utmost importance. Under an aristocratic régime, science, like arts and letters, must be cultivated and patronized from above. In Germany the imperial government has directed and subsidized its schools, universities and research institutions and has aided commercial enterprises based on applied science. In England men of wealth have devoted themselves to scientific research, as they have served without payment as county magistrates and members of parliament. In both countries and in France titles and social position have been used as rewards.

Scientific research can not be undertaken as a profession. In the existing organization of society any service to an individual or to a group of individuals is paid for by them, but service to society is usually not paid for at all. If newspaper publishers, ammunition makers or army officers succeed in causing war they profit; if they advocate and maintain peace they suffer. If lawyers reduce legal complexities and delays, or if physicians decrease the causes of disease, they sacrifice their material interests. If a surgeon performs an operation for cancer he may be paid a thousand dollars for an hour's work; if he discovers an improved technique he may profit somewhat, but scarcely more than other surgeons and far less than the patients; if he should discover a cure for cancer he would receive no money reward; on the contrary, he and other surgeons would in so far lose their means of supporting their families.

So scientific research, of greater value than any other service to society, is not paid for directly. It has been mainly carried forward in this country by men employed to teach in colleges and universities who, as amateurs, give part of their time to it. In recent years the national government, endowed institutions and industrial establishments have undertaken to advance research on a business basis and the gain has been very great. But in order to maintain and increase the work under democratic control people must be taught to value it, and for this purpose the proper treatment of science in magazines and newspapers is more important than any other agency.

The problem is very difficult. One does not expect a high school, a university or a museum to be self-supporting. Even secondary schools for the children of the rich are endowed. If the American Museum of Natural History charged an entrance fee it would be an empty place; the fees for a year would not support the institution for a month. On the other hand, the side shows of a circus may be profitable. Science is so commonly ill-treated in popular magazines and newspapers that the very words "popular science" need to be redeemed. The sensational newspapers, the side shows of the circus and the "movies" supply what people will pay for. It is no discredit to our democracy that these are what they want; on the contrary, it represents a great advance when a hundred million people care for such things. We may be satisfied if progress is made by education and an improved environment in a hundred years if a slightly better germplasm is established in a thousand years.

The corporation of D. Appleton and Company were losing ten thousand dollars a year on THE POPULAR SCIENCE MONTHLY when they decided that they were not justified in continuing it. It was worth that much and far more to

the people, just as the American Museum of Natural History is worth three hundred thousand dollars a year and Columbia University is worth four million dollars a year. But a private corporation can not be expected to subscribe indefinitely ten thousand dollars a year for the benefit of the public. The weekly journal *Science* was in like manner supported for a time by Dr. A. Graham Bell and Mr. Gardiner G. Hubbard, at a total expense of about eighty thousand dollars. There are over a hundred journals and proceedings devoted to the publication of research work in America not one of which pays its expenses on a regular business basis. Magazines connected with applied science and popular mechanics may do so. This represents a step in advance, which we may hope indicates that ultimately there may be a general interest in other and more fundamental departments of science.

It would probably be undesirable for scientific journals to be directly subsidized or endowed. Indirectly they are now subsidized by the work of contributors and editors supported by endowed or tax-supported institutions and by subscriptions from public libraries. In so far as they require additional support, it can probably best come through an increase in the number of public libraries subscribing for such journals and by an increase of subscribers among those who may realize the importance of supporting an institution essential to society and its betterment.

SCIENCE AND NATIONAL WELFARE

One of the alleviating circumstances in the disaster of this war is the fact that it thrusts on the attention of all the place that science holds in national and international affairs. Science does not necessarily or at once make us moral or wise, although its general influence is in this direction. Human nature can not be greatly altered by a change in the environment effective for a short period and on some individuals. But when the new conditions become general and individuals are favored who fit into them, so that an altered race is preserved by natural selection, science will make our morality and enforce its observance. We may look forward to the

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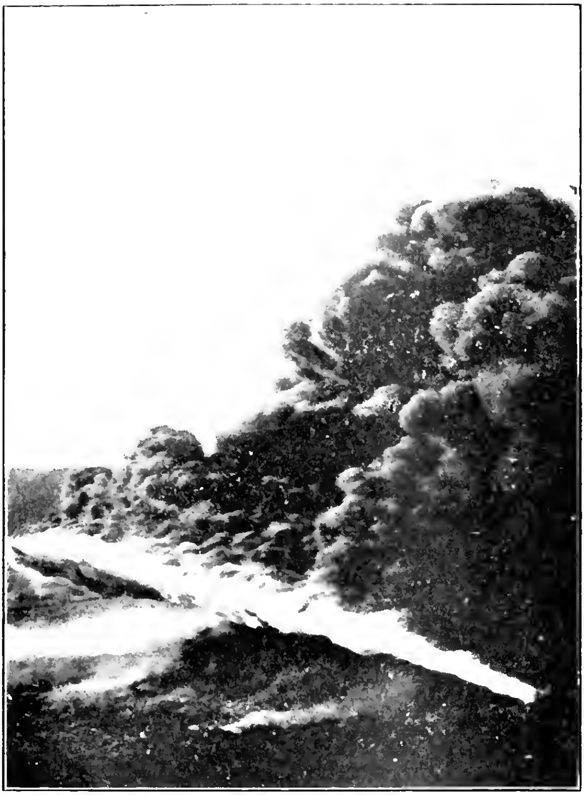
Field Railway used in the German Advance in Russia. Within a week of the capture of Warsaw an express railway service has been established between Lille and Warsaw.



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THE SO-CALLED "LIQUID FIRE" USED BY THE GERMANS IN REPULSING ATTACKS.

time when war will be no part of this morality and will no longer exist.

Those who can not understand or do not accept the argument that science will ultimately control human conduct must be convinced by the brute argument of accomplished fact that science is essential to national efficiency. Germany, against superior numbers, advances its lines in Poland and Russia and holds them in Flanders and France, it adjusts the nation to be self-supporting and self-sufficient, because it has a better organization of science than the other nations. Germany did not spend so much *per capita* on its army and navy as Great Britain or France, but it spent more on science and regarded science more highly. It has been stated that the British government at present employs 17 chemists, the German government about 1,000. We hear it said that Germany has developed an efficient military machine by subordinating the individual to discipline from above. It is not less true that the German university has been one of the most anarchic of institutions—both students and professors having had freedom greater than they have in American universities—and at the present moment Germany owes more to its universities as they have been conducted in the past than to its army as it is now organized.

A complicated machine is not useful in order to meet an emergency, but rather the scientific attitude and the scientific training which can react to the new situation. A superdreadnaught

built at a cost of $15,000,000 may be an asset or a burden. An equal sum spent in selecting and educating 3,000 scientific men would nearly double the number of men the country competent to advance science. The dreadnaught is a continual expense, it depreciates at the rate of a million dollars a year, its existence tends to exert an influence toward a war of aggression. The three thousand scientific men would add to the wealth of the country in peace, to its strength in a war of defense. If two years ago the officers of the German army had been put on the ships of the British navy and the ships had been sunk in the Atlantic, it would have been for the welfare of the world. If the number of men engaged in scientific research and in the applications of science could be doubled, the gain would be incalculable.

If we wish to make the nation strong in defense we should care for our children and our schools, for our scientific men and our universities—in this particular number of THE POPULAR SCIENCE MONTHLY it may be permitted to add—for our journals devoted to the diffusion and advancement of science.

SCIENTIFIC ITEMS

WE record with regret the death of Frederick Ward Putnam, the distinguished anthropologist of Harvard University; of Dr. John Ulric Nef, head of the department of chemistry of the University of Chicago, and of Dr. Joseph Austin Holmes, director of the U. S. Bureau of Mines.

THE American Association for the Advancement of Science held a successful meeting at San Francisco, Berkeley, and Stanford University, during the first week of August. The address of the president, Dr. W. W. Campbell, director of the Lick Observatory, which was printed in the issue of *Science* for August 20, is entitled "Science and Civilization."

A MARBLE chair is to be placed in the open-air Greek Theater of the University of California in honor of Eugene Waldemar Hilgard, professor of agriculture and dean of the College of Agriculture from 1875 to 1906, and now professor emeritus.—Professor R. A. Millikan, of the department of physics, has been elected president of the University of Chicago Chapter of Phi Beta Kappa.

DR. WILLIAM H. WELCH, professor of pathology in the Johns Hopkins University, and Dr. Simon Flexner, director of the laboratories of the Rockefeller Institute for Medical Research, have sailed for China where they go on behalf of the China Medical Board of the Rockefeller Foundation to report on the medical schools and hospitals.—The schooner *George B. Cluett*, chartered by the Crocker Land relief expedition to go in quest of Donald B. MacMillan and the members of his party in Greenland, has sailed from North Sydney, Nova Scotia. Dr. Edmund Otis Hovey, of the American Museum of Natural History, chairman of the Crocker Land Exploration Committee, is in charge.

GOVERNOR DUNNE has signed the bill giving $5,000,000 to the University of Illinois for the biennium. It is the largest grant made in a single law to any university in the United States.

INDEX

The Popular Science Monthly—July, August, September

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